SURFACE-WATER AND GROUND-WATER RIGHTS STUDY IN THE VICINITY OF ROCKY FLATS PLANT

Task 14
of the
Zero-Offsite Water-Discharge Study

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Surface-Water and Ground-Water Rights Study in the Vicinity of Rocky Flats Plant

EXECUTIVE SUMMARY

This report has been prepared for one of several studies being conducted for, and in the development of, a Zero-Offsite Water-Discharge Plan for Rocky Flats Plant (RFP) in response to Item C.7 of the Agreement in Principle (AIP) between the Colorado Department of Health (CDH) and the U. S. Department of Energy (DOE) (DOE and State of Colorado, 1989). The CDH/DOE Agreement Item C.7 states "Source Reduction and Zero Discharge Study: Conduct a study of all available methods to eliminate Rocky Flats discharges to the environment including surface waters and ground water. This review should include a source reduction review" (AIP, p. 8).

This surface-water and ground-water rights study has assessed the hydrologic characteristics of streams and aquifers in the vicinity of the RFP. The purpose of this assessment was to give a preliminary analysis of potential injury to both surface-water and ground-water rights downstream from the RFP for various preferred alternatives related to zero-offsite water discharge from the RFP and for alternatives to zero discharge from the RFP such as on-site irrigation of pasture grass, off-site irrigation of landscaping at the new Denver airport, or off-site water reuse at the Denver Water Department Potable Reuse Plant.

The RFP purchases about 395 acre-feet per year (ac-ft/yr) (about 129 million gallons per year (mgy)) of trans-mountain and trans-basin water from the Denver Water Board. Previous legal opinions (Holland & Hart, Attorneys at Law, 1990; Holme, Roberts and Owen, Attorneys at Law, 1990), and correspondance between DOE and the DWB (DOE, 1979) indicates that this water may not have to be returned to the South Platte River basin to satisfy downstream water rights. The DWB, however, may require return of a all or part of the purchased water, but the existing DOE contract with the Denver Water Board does not address this return flow. A possible worst

case would be that the RFP would have to replace historical STP effluent discharges which have averaged about 237 ac-ft/yr (about 77 mgy) during the 1986 through 1990 period.

Surface-water runoff from that part of the RFP where future runoff may be controlled (areas varying from 1.9 mi^2 to 5.5 mi^2), could have an estimated average annual runoff of about 125 ac-ft (41 million gallons (mg)) and 280 ac-ft (91 mg), respectively. Because all or part of this runoff would be diverted out of priority, it would require replacement or augmentation, at least during the months of April through October, during all years. Assuming a dry year with replacement or augmentation water governed by South Platte River calls, the average annual quantity of water which must be replaced or augmented by the RFP may range from about 110 ac-ft (36 mg) to 233 ac-ft (76 mg) depending upon the selected zero-discharge alternative. The average annual quantity of ground water which may have to be replaced or augmented is unknown at this time, but has been assumed to be on the order of 10 ac-ft (3 mg) (DOE, 1991). Thus, the total estimated average annual quantity of replacement or augmentation water for various preferred zero-discharge options and alternatives to zero discharge may vary from 120 (39 mg) ac-ft to 480 ac-ft (156 mg). This estimate include the average annual STP effluent and the average annual ground-water quantity.

Non-tributary ground water beneath the RFP could be used to provide replacement or augmentation water to downstream water rights. The estimated legally recoverable quantity of non-tributary ground water in the Arapahoe and Larimie-Fox Hills aquifers underlying the RFP is about 127,000 ac-ft (41,380 mg) under current applicable resource-management guidelines. The Colorado State Engineer would permit this water to be extracted at a rate of about 780 gpm over a 100-year period. However, not all of this water could easily or economically be extracted.

Additional sources of water which could be used as replacement or augmentation water for downstream senior water rights would vary, depending upon the zero-discharge alternative implemented. These sources may include leasing surface water from rights in the Clear Creek basin or South Platte River basin from an existing water-right holder, such as Coors (Neil Jaquet,

personal communication). Such a lease agreement should include the quantity, timing and quality of the water which would be released over a specified duration. If DOE purchases Great Western Reservoir as indicated in the Rocky Flats Surface Water Management Plan (DOE,1991) the water rights for this Reservoir also should would be purchased. These water rights include storage of 1,595.74 ac-ft (520 mg) annually with a storage capacity of 3,250 ac-ft (1,059 mg). The City of Broomfield also owns nearly 2000 inches of Church Ditch water having an annual yield of between 2,000 ac-ft (652 mg) (City of Broomfield records) and 3,000 ac-ft (977 mg) (Colorado State Engineer's records). This Church Ditch water right should be included in the Great Western Reservoir purchase. The Great Western Reservoir and Church Ditch water rights could be used as augmentation or replacement water if water-quality considerations are addressed. If DOE purchases Great Western Resrvoir, the Colorado Department of Health may claim that the quality of water in the reservoir must meet or exceed that rather stringent numeric stream standards currently in effect on Walnut Creek.

Studies that are subordinate to the Zero-Offsite Water-Discharge Plan that will be affected by or will affect this preliminary water-rights study are: Water-Yield and Water-Quality Study of Walnut Creek and Woman Creek Watersheds (Task 4), Confirmation of Rainfall/Runoff Relationships Study (Task 5), Storm Runoff Quantity for Various Design Events Study (Task 6), Design Recurrence Intervals Study (Task 9), Treated Sewage/Process Wastewater Recycle Study (Tasks 11 and 13), Surface-Water Evaporation Study (Task 15), Water-Yield and Water-Quality Study of Other Sources Tributary to Standley Lake and Great Western Reservoir (Task 16), Alternatives to Zero Discharge Study (Task 17), Temporary Water-Storage Capabilities Study (Task 21), Ground-Water Recharge Study (Task 22), Study of Water Resource Management (Task 23), Bypass Upstream Flows Around Rocky Flats Plant Study (Task 24), Feasibility of Ground-Water Cutoff and Diversion Study (Task 26), Augmentation Plan for the Rocky Flats Plant (Task 28), Non-Tributary Ground-Water Study (Task 29), and Consolidation and Zero Discharge Plan (Task 30).

Surface-Water and Ground-Water Rights Study in the Vicinity of Rocky Flats Plant

1.0 INTRODUCTION

1.1 BACKGROUND

This report has been prepared for one of several studies being conducted for, and in the development of, a Zero-Offsite Water-Discharge Plan for Rocky Flats Plant (RFP) in response to Item C.7 of the Agreement in Principle (AIP) between the Colorado Department of Health (CDH) and the U. S. Department of Energy (DOE) (DOE and State of Colorado, 1989). The CDH/DOE Agreement Item C.7 states "Source Reduction and Zero Discharge Study: Conduct a study of all available methods to eliminate Rocky Flats discharges to the environment including surface waters and ground water. This review should include a source reduction review" (AIP, p. 8).

1.2 SCOPE AND PURPOSE

This water-rights study has tabulated surface-water points of diversion in the Big Dry Creek basin downstream from the RFP. A preliminary analysis of the potential injury to downstream surface-water rights and the downgradient ground-water rights as a result of zero-offsite water discharge will be made. The historic diversions of selected water rights available from the Colorado State Engineer and Water Commissioner's field books have been tabulated and analyzed. Also, the hydrology of the Big Dry Creek basin was summarized. Wells presented in the water-rights tabulations of the Colorado State Engineer were field checked to the extent possible to see if the permits have been exercised. A summary of the well information have been tabulated for wells near the RFP. The hydrogeology of individual aquifers underlying the RFP was summarized. The surface-water and ground-water rights considerations related to zero-offsite water discharge

then are summarized, based upon generalized potential zero-discharge alternatives derived from Task 17 (ASI, 1991e) and Task 21 (ASI, 1991d).

This preliminary water-rights study is related to the Zero-Offsite Water-Discharge Study (ASI, 1990a) and includes the following: (1) an inventory of the existing surface-water and ground-water rights in the Big Dry Creek basin and in the vicinity of the RFP; (2) preparation of "straight-line" diagrams showing the location of surface-water rights, and a map showing the location of ground-water rights; (3) review of the Denver Board of Water Commissioners (DWB) agreement with the DOE to provide water to the RFP (DWB and DOW Chemical Company, 1952); (4) preliminary hydrologic analyses of Walnut Creek, Woman Creek and Big Dry Creek in the vicinity of the RFP; (5) preliminary analyses of South Platte River call records from the Colorado State Engineer; (6) preliminary analyses of the hydrogeology of alluvial and bedrock aquifers in the vicinity of the RFP; (7) estimates of the quantity of non-tributary ground water in storage beneath the RFP; and (8) assessment of water-rights considerations related to selected proposed zero-offsite water discharge alternatives from other subordinate study tasks.

Because the actual zero-discharge plan for the RFP is still being fomulated as Task 30 of the Zero-Offsite Water-Discharge Study (ASI, 1990a), the water-rights analyses presented here are generalized. Because this report was prepared without benefit of legal counsel, the details presented in this study may not be sufficient for water rights engineering preparation for Colorado Water Court. Where possible, water-rights legal opinions provided by previous studies (ASI, 1990a; DOE 1991) have been incorporated.

Studies which are subordinate to the Zero-Offsite Water-Discharge Study that would be affected by or affect this preliminary water-rights study are: Water-Yield and Water-Quality Study of Walnut Creek and Woman Creek Watersheds (Task 4, ASI, 1990e), Confirmation of Rainfall/Runoff Relationships Study (Task 5, ASI, 1991j), Storm Runoff Quantity for Various Design Events Study (Task 6, ASI, 1991b), Design Recurrence Intervals Study (Task 9, ASI, 1990c), Treated Sewage/Process Wastewater Recycle Study (Tasks 11 and 13, ASI, 1991a),

Surface-Water Evaporation Study (Task 15, ASI, 1991h), Water-Yield and Water-Quality Study of Other Sources Tributary to Standley Lake and Great Western Reservoir (Task 16, ASI, 1990f), Alternatives to Zero Discharge Study (Task 17, ASI, 1991e), Temporary Water-Storage Capabilities Study (Task 21, ASI, 1991d), Ground-Water Recharge Study (Task 22), Study of Water Resource Management (Task 23, ASI, 1991i), Bypass Upstream Flows Around Rocky Flats Plant Study (Task 24, ASI, 1991c), Feasibility of Ground-Water Cutoff and Diversion Study (Task 26, ASI, 1991h), Augmentation Plan for the Rocky Flats Plant (Task 28), Non-Tributary Ground-Water Study (Task 29, ASI, 1991f), and Consolidation and Zero Discharge Plan (Task 30). Input from those subordinate tasks which have been initiated, as referenced, were used in this study where appropriate.

2.0 SURFACE WATER

2.1 HYDROLOGIC SETTING

The RFP is drained by Walnut Creek and Woman Creek, which are part of the Big Dry Creek basin and by Rock Creek, a part of the Coal Creek basin (Figure 1). The RFP is located in former Water Districts 2 and 6 as defined by the Colorado State Engineer (1979). In 1969, the Colorado Legislature abolished the water districts and established seven water divisions encompassing the seven major river basins in the State (Knudsen and Danielson, 1977). The RFP is located in Water Division 1 (South Platte River basin). Although water districts are no longer legally recognized, this jurisdictional delineation is still being used by the Colorado State Engineer for administrative purposes (Knudsen and Danielson, 1977) and also is used in this report. Big Dry Creek and its tributaries are located in Water District 2 and Rock Creek is located in Water District 6. The Clear Creek basin, in Water District 7, is south of the RFP and Water Districts 2 and 6. Big Dry Creek is tributary to the South Platte River basin, with the Big Dry Creek confluence with the South Platte River about 1.5 miles south of Fort Lupton (Figure 1).

There are several ditches, originating in Water District 6, which convey water across the RFP area as shown on Figure 2. These ditches, which are discussed in more detail below, include the Upper Church Ditch, the McKay (Zang) Ditch, and the Kinnear Ditch. The Upper Church Ditch diverts water from Coal Creek in Water District 6 (Figure 1) into Water District 2. The Upper Church Ditch enters the RFP site just north of the west access road and proceeds generally northeast (Figure 2). This ditch exits the RFP in the northeast corner of the site at about the intersection of Colorado Highway 128 and North Indiana Street. The McKay Ditch, also known as the Zang Ditch, diverts water from Coal Creek in Water District 6 into Water District 2. The McKay Ditch generally runs parallel to the Upper Church Ditch until it enters the McKay Bypass, where it then runs in a more east-southeasterly direction than the Upper Church Ditch. The McKay bypass was constructed by DOE, to prevent ditch water from flowing down Walnut

Creek into the RFP's A-series ponds. The McKay Bypass re-enters Walnut Creek downstream from Pond A-4 (Figure 2) and ultimately flows into Great Western Reservoir. The Kinnear Ditch also diverts water from Coal Creek. This ditch flows generally easterly across the RFP and discharges into Woman Creek. Kinnear Ditch water ultimately flows into Standley Lake.

Two other ditches convey water across the RFP. These two ditches are the Smart Ditch and the Mower Ditch. The Smart Ditch diverts water from Rocky Flats Lake, west of the RFP, and conveys this water eastward across the south Buffer Zone to Standley Lake. The Smart Ditch exits the RFP at the southeast corner of the site. The Mower Ditch diverts water from Woman Creek into Mower Reservoir (Figure 2).

Nearby ditches which convey water in the vicinity of the RFP include the Last Change Ditch, the South Boulder Diversion Canal, the Church Ditch, the Croke Canal and the Farmers Highline Canal. The Last Chance Ditch diverts water from Coal Creek (Figure 2). Water diverted by the Last Chance Ditch generally flows along the south side of the RFP site and flows into Standley Lake. The South Boulder Diversion Canal diverts water from South Boulder Creek to Ralston Reservoir (Figure 2). The RFP raw water supply also comes from the South Boulder Diversion Canal, or from Ralston Reservoir if the Canal is not flowing. The Church Ditch diverts water from Clear Creek (Water District 7) to Great Western Reservoir where the water is pumped into the Reservoir. Water also is imported to Water District 2 from Water District 7 (Clear Creek) through the Croke Canal, which discharges into Standley Lake. The Farmers Highline Canal also diverts water from Clear Creek and discharges into Standley Lake.

2.2 ROCKY FLATS PLANT WATER SUPPLY

The RFP purchases raw water for both domestic and industrial use from the Denver Board of Water Commissioners (DWB) (Holland & Hart, Attorneys at Law, 1990). Raw water for the RFP is either diverted directly from the South Boulder Diversion Canal or is pumped approximately 5.7 miles (mi) from Ralston Reservoir. Both of these water sources rely upon

trans-mountain diversion water. Water from the South Boulder Diversion Canal is the primary RFP raw water source due to both proximity and gravity flow. Water is pumped from Ralston Reservoir only when the South Boulder Diversion Canal is not flowing, usually during the winter.

The contract for sale of water to the RFP was entered into between the City and County of Denver, acting through its Board of Water Commissioners, and the Dow Chemical Company, the then-operator of the RFP, on October 28, 1952 (DWB and DOW Chemical Company, 1952). Interpretation of the contract by Holland & Hart, Attorneys at Law (1990) indicated that the DWB would furnish water to the RFP at a rate of 1.5 million gallons per day (mgd), and that the contract would automatically be renewed from year to year unless notice to the contrary was given. The future water supply available to the RFP from the DWB is subject to future needs and requirements for water of the City and County of Denver. The contract is assignable to any successor to Dow as operator of the RFP. Further interpretation of the contract by Holland & Hart indicated that the contractual provisions did not indicate that the raw water supplied by the DWB could not be used and reused to extinction by the operator of the RFP. Although water diverted by the DWB and supplied to its various customers is subject to system-wide return-flow obligations, Holland & Hart's analysis indicated no authority which would require an individual recipient of DWB water to return a specified percentage of that water to the stream after its initial use. It should be noted that if the DWB were to notify the RFP that the contract in future years would be changed to reflect a return flow provision, then zero discharge options may require replacement of water which would have been returned after its initial use.

DOE also obtained a legal opinion from Holme, Roberts and Owen, Attorneys at Law (1990), regarding return flows from DWB water sold to the RFP. Holme, Roberts and Owen indicated that because the source of the purchased water is trans-basin and trans-mountain, the appropriator of such water (that is, the DWB) has the right to use and reuse such water to extinction. However, because the RFP contract is on a year-to-year term, the concurrence of the DWB related to zero discharge would be advisable. The DWB may require that some of the water used at the RFP be returned, and that these return flows be to the South Platte River basin.

In October 1978, Rockwell International, then operator of the RFP, asked the DWB for a letter clarifying the status of reuse of water supplied by the DWB (Rockwell International, 1978). In November 1978, the DWB responded to Rockwell International (DWB, 1978) that pending negotiation of a new contract between Rockwell/DOE and the DWB, reuse of water was prohibited. In July 1979, the DWB permitted DOE to place the reverse osmosis (RO) water treatment plant at the RFP into operation and to reuse water from the RO plant (DOE, 1979). The RO plant at the RFP had the capability to treat 648,000 gallons per day (gpd) if operated continuously. This capacity could reuse all of the estimated RFP sanitary effluent of 237 acre-feet per year (ac-ft/yr) or about 77 million gallons per year (mgy). Therefore, it is judged that the DWB was aware that total reuse of purchased water at the RFP was possible and that the DWB agreed to this total reuse.

Both Holland & Hart, Attorneys at Law (1990) and Holme, Roberts and Owen, Attorneys at Law (1990) recognized that under Colorado water law, absent bad faith, the point of discharge of wastewater or effluent may be changed by the discharger, even if that change adversely affects other water users. Therefore, they concluded that the RFP could reuse its sanitary treatment plant (STP) effluent from DWB purchased water without having to replace water, even though it might adversely affect a downstream water right.

Historical water purchases from the DWB by the RFP have been compiled by others based upon RFP data (ASI, 1988; 1990g; 1991a; 1991d). Table 1 shows the raw water purchased from the DWB for the years 1971, 1972, 1980 through 1987, and 1989, the last complete year of data. Data on water purchases were not available for the years 1973 through 1979, or for 1988. The average annual water purchases for the 11-year period were about 395 ac-ft/yr (about 129 mgy), and ranged from 283 ac-ft/yr (92 mgy) in 1981 to 596 ac-ft/yr (194 mgy) in 1971. Typically, the RFP discharges between 227 ac-ft/yr and 237 ac-ft/yr (between 74 mgy and 77 mgy) of effluent from the STP. Thus, the RFP, under average conditions, may have to replace this water, about 237 ac-ft annually, if the DWB changed the water purchase contract to explicitly prohibit purchased water reuse to extinction.

Table 1

Raw Water Purchased from the Denver Board of Water Commissioners

Year		Raw Water Purchased (gallons)	Raw Water Purchased (ac-ft)
1971[2)]		194,030,000	595.5
1972[2)]		175,590,000	538.9
1980		108,038,000	331.6
1981		92,098,000	282.7
1982		101,591,000	311.8
1983		106,406,000	326.6
1984		125,768,000	386.0
1985		131,197,000	402.7
1986		133,677,000	410.3
1987		127,093,000	390.1
1988		---[1)]	---[1)]
1989		121,394,000	372.6
	Average	128,807,454	395.4

1) No data available for 1988.

2) Source: Hurr, 1976.

Note: No data available for 1973 through 1979.

2.3 HYDROLOGY OF WALNUT CREEK AND WOMAN CREEK

In order to estimate the quantities of surface-water runoff which may have to be replaced for various scenarios of zero discharge, estimates of yield from the existing Walnut Creek and Woman Creek basins are needed. This section presents hydrological characteristics, historical data, and estimates of basin yield for these two drainage basins in the vicinity of the RFP.

2.3.1 Walnut Creek

Walnut Creek and South Walnut Creek have their head waters on the RFP and flow eastward (Figures 1 and 3). South Walnut Creek is tributary to Walnut Creek which flows into Great Western Reservoir (Figure 1). Walnut Creek is tributary to Big Dry Creek. The confluence of these two creeks is located about 3.1 mi downstream from Standley Lake dam. Water in the Walnut Creek basin moves through stream and man-made channels and culverts within the RFP area as a result of surface runoff following periods of rainfall and snowmelt. Although Walnut Creek is generally ephemeral over its length, baseflow is supplied by seeps, springs, irrigation diversions, wastewater from various man-related activities, and overflows from the South Boulder Diversion Canal. The network of storm culverts within the Controlled Area of the RFP (Figure 2) and RFP ponds along both South Walnut Creek and Walnut Creek affect the rate of water movement in the basin. Much of the water measured at various locations within the South Walnut Creek and Walnut Creek basins is the result of imported water from DWB water purchases and irrigation diversions from Coal Creek wast of the RFP. The general hydrologic relationships between the gaged streams of this complex system is discussed below. Physical characteristics at selected locations within the South Walnut Creek and Walnut Creek basins are listed in Table 2.

Until September 1974, Walnut Creek drained an area of about 1.24 mi^2 above the inactive U. S. Geological Survey (USGS) gaging station 06720780 (Figure 3). The natural streamflow of the basin was augmented by diversions from Coal Creek through the Upper Church and McKay

(Zang) ditches (Figure 1). The Walnut Creek Diversion Dam and McKay Bypass Canal (Figures 1 and 3) were constructed in September 1974 to route the McKay Ditch flows north of the RFP Controlled Area. The McKay Bypass joins a small unnamed tributary of Walnut Creek which re-enters the Creek about 1,200 feet (ft) downstream from the confluence of South Walnut Creek and Walnut Creek (Figures 1 and 3). The Walnut Creek Diversion Dam and McKay Bypass effectively intercept all of the streamflow from upstream. The remaining drainage basin area at USGS gaging station 06720780 was about 0.8 mi^2, according to Hurr (1976). Currently, the drainage area upstream from the South Boulder Diversion Canal (Figure 3) is not included in this drainage area.

The inactive USGS gaging station 06720780 on Walnut Creek operated from about July 1972 until November 1975. Measured discharges at that Walnut Creek station are summarized in Table 3. After construction of Pond A-4 (Figure 3) in about 1980, discharge measurements have been made downstream of Pond A-4 by RFP personnel. Much of the measured water from Pond A-4 is the result of captured surface-water runoff and ground water inflow which originates on the RFP property. Water from other drainage basins also may be included, because water may be routed from South Walnut Creek into Walnut Creek via a series of pipes. Additionally, water pumped from Pond C-2 (Figure 3) also may flow into Pond A-4. The water from Pond C-2 is water which would have discharged into Woman Creek but is currently intercepted by the South Interceptor Canal (Figure 3). Because Pond A-4 currently is the location of water treatment prior to release under a National Pollutant Discharge Elimination System (NPDES) permit, the measured discharges downstream from Pond A-4 also may include treated STP effluent.

South Walnut Creek above inactive USGS gaging station 06720790 (Figure 3) had a drainage area of about 0.46 mi^2 according to Hurr (1976). Re-routing of runoff within the RFP Controlled Area between about 1976 and present has reduced this effective drainage area to about 0.35 mi^2. The USGS station on South Walnut Creek operated from about July 1972 through December 1974. The measured discharges at this station are summarized in Table 3. In about 1980, Pond B-5 was constructed as a terminal storage pond in South Walnut Creek. Discharges currently are

Table 2

Summary of Drainage Basin Characteristics for Walnut Creek and Woman Creek In the Vicinity of Rocky Flats

Sub Basin Location	Area (mi^2)	Length (ft)	Slope (ft/mi)
Walnut Creek			
Walnut Creek at Great Western Reservoir Dam	5.5	28,100	113
Walnut Creek at Indiana Street	2.9	22,600	128
Walnut Creek at Pond A-4[2]	0.63	10,200	166
Walnut Creek at USGS Gaging - Station 06720780	1.2	8,400	171
South Walnut Creek at Pond B-5[1]	0.41	9,500	170
South Walnut Creek at USGS Gaging - Station 06720790	0.35	7,900	160
Woman Creek			
Woman Creek at Indiana Street	2.8	30,100	145
Woman Creek at USGS Gaging - Station 06720700	2.1	23,600	156
Woman Creek at Pond C-1[2]	1.7	21,700	156
Woman Creek at USGS Gaging - Station 06720690	1.8	20,100	158
Woman Creek at Pond C-2[3]	0.35	7,900	167

1) Does not include area upstream from the Walnut Creek Diversion Dam (ASI, 1991d).

2) Does not include area diverted into Pond C-2 by the South Interceptor Canal (ASI, 1991d).

3) Source: ASI (1991d).

Table 3

Monthly and Annual Discharges at Selected Locations in the Walnut Creek Basin near Rocky Flats Plant

Summary of Measured Discharge Walnut Creek at Indiana Street[2)] (Ac-Ft)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1986	--[3)]	--	--	--	--	--	--	--	--	--	19.5	11.8	--
1987	18.8	32.9	0	16.5	44.0	312	679	248	136	94.9	51.2	17.9	1,651
1988	0	5.6	0	0	23.1	92.1	254	647	223	0	0	45.5	1,290
1989	0	13.5	10.4	0	11.8	2.5	26.2	0.4	13.4	0	32.2	56.2	167
1990	19.5	0	0	0	0	48.9	108	45.7	0.2	0	65.2	14.4	302
1991	22.3	--	--	--	--	--	--	--	--	--	--	--	--

1) Source: EG&G Rocky Flats, Inc.

Summary of Measured Discharge Walnut Creek at USGS Gaging Station 06720780[1)2)] (Ac-Ft)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1972	--	--	0	--	--	--	--	--	11	0	10	8.7	--
1973	0.5	1.8	2.9	13	15	41	232	175	1.8	1.2	0	2.2	486
1974	3.9	2.3	16	53	37	92	--	--	--	--	0	0	--
1975	0	--	--	--	--	--	--	--	--	--	--	--	--

1) Source: Hurr (1976)

Summary of Measured Discharge South Walnut Creek at USGS Gaging Station 06720790[1)2)] (Ac/Ft)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1972	--	--	--	--	--	--	--	--	--	22	18	24	--
1973	13	21	17	20	16	22	48	193	24	16	8.2	19	417
1974	16	10	18	19	12	18	25	9.7	9.6	1.4	2.2	2.1	143

1) Source: Hurr (1976)
2) Values include water imported to the basin for domestic, industrial and irrigation uses.
3) -- No data available.

monitored by RFP personnel downstream from Pond B-5 under an NPDES permit. Much of the water monitored downstream from Pond B-5 is STP effluent mixed with surface-water runoff from the RFP.

Streamflow also has been measured since October 1986 by RFP personnel in Walnut Creek at Indiana Street (Figure 3). Discharges at this location represent a sum of the releases from Ponds A-4 and B-5 as well as runoff from the intervening drainage area between the two ponds and Indiana Street. The discharges measured in Walnut Creek at Indiana Street are summarized in Table 3. These discharges include irrigation water diverted by the McKay ditch as well as surface-water runoff and STP effluent. Therefore, it is very difficult to estimate the quantity of water contributed by runoff alone as measured in the Walnut Creek basin. Diversions by the McKay Ditch are summarized later in this report.

Water yield estimates of the drainage basins at the RFP were made by ASI (1990e). This water yield study estimated average monthly and annual quantities of water which would be yielded from RFP watersheds under natural conditions, i.e. without the RFP or imported water from irrigation ditches. Because on-site RFP runoff data were not adequate to permit direct calculation of monthly or annual water yield from RFP streams, a regional regression analysis was undertaken (ASI, 1990e). Seasonal (April-through-October) water yields from 28 USGS rainfall-runoff gaging stations with approximately 10 years of record were related to drainage basin physical characteristics such as drainage area, mean annual precipitation, mean basin elevation and basin relief, stream channel slope and mean drainage basin slope. Results of a multiple-regression analysis were that seasonal water yield, adjusted to long-term average annual water yield, best relates to effective drainage area alone in the form of the following equation (ASI, 1990e):

$$Q_a = 13.986\ A^{0.7574} \qquad (1)$$

where: Q_a = Long-term average annual water yield in ac-ft, and

A = Effective drainage area in mi^2.

Long-term average annual estimates of water yield for Walnut Creek at various locations based upon equation (1) are given in the following table.

Estimates of Long-Term Average Annual Water Yield for Natural-Flow Conditions in the Walnut Creek Basin

STREAM	DRAINAGE AREA (sq mi)	ANNUAL YIELD (ac-ft)
Walnut Ck. @ Great Western Res.	5.5	50.9
Walnut Creek @ Indiana Street	2.9	31.3
Walnut Creek @ Pond A-4	0.63	9.9
South Walnut Ck. @ Pond B-5	0.41	7.1

During any ten-year period, the annual water yield would to range from zero to approximately four times the long-term average annual water yield shown above.

The distribution of annual water yield on a monthly basis was estimated by examining the distribution of annual runoff at several long-term USGS gaging stations, and by examining the distribution of runoff at the 28 rainfall-runoff gaging stations (ASI, 1990e). Monthly water yield, as a percent of annual water yield (AY), can be estimated from the distribution given below. Estimates of long-term average monthly water yield, in ac-ft, for the four Walnut Creek sites previously described is given below.

Estimates of Long-Term Monthly Water Yield for Natural-Flow Conditions in the Walnut Creek Basin

(Ac-Ft)

% AY	Oct 1	Nov 1	Dec 1	Jan 1	Feb 1	Mar 4	Apr 5	May 16	Jun 24	Jul 20	Aug 20	Sep 6
Wal. C. @ GWR	0.6	0.5	0.5	0.5	0.5	2.0	2.5	8.1	12.2	10.2	10.2	3.1
Wal. C. @ Ind.	0.3	0.3	0.3	0.3	0.3	1.3	1.6	5.0	7.5	6.3	6.2	1.9
Wal. C. @ A-4	0.1	0.1	0.1	0.1	0.1	0.4	0.5	1.6	2.4	2.0	2.0	0.5
S. Wal. C. @ B-5	0.1	0.1	0.0	0.1	0.1	0.3	0.4	1.1	1.7	1.4	1.4	0.4

The above annual and monthly water yields, calculated from equation (1) and the AY distribution, are estimates of long-term averages, and are not applicable for predicting water yields for a specific year or a month withinin a specific year. Also, these are estimates of annual and monthly water yield for natural-flow conditions. These do not consider potential increased runoff from such factors as irrigation diversions, flood overflows across drainage divides, man-made diversions of runoff, impervious areas such as buildings and parking lots, nor do the estimates consider reduced runoff as a result of storage of water in reservoirs and subsequent evaporation.

Monthly and annual water yield estimates were made for a typical RFP drainage basin for the current basin conditions of about 30 percent impervious area (Task 21, ASI, 1991d). Efforts related to the Task 21 study generated 10 series of equally likely monthly synthetic flow sequences for a typical 1.0 mi^2 RFP drainage basin with 30 percent impervious area. These monthly flow sequences were generated using Monte-Carlo techniques available from Fiering and Jackson (1971), Yevjevich (1972), Kunkel (1974) and Shen (1976). The monthly synthetic flow sequences were based upon about 12 years of monthly flow data collected by the USGS from Big Dry Creek at Littleton, Colorado (Ducret and Hodges, 1972, 1975; Cochran and others, 1979, 1983; and Mustard and others, 1987). It was assumed that the underlying statistical distributions of the original USGS data were either normal, log-normal or gamma.

The results of the generated sequences (ASI, 1991d) suggested that the normal distribution preserved the monthly mean values within 35 percent of the original monthly streamflow data mean, and

preserved the variance within less than 1 percent of the original streamflow data variance. The results of the generated sequences also suggested that the log-normal distribution preserved the mean within 51 percent of the original streamflow data mean and the variance within 163 percent of the original streamflow data variance. The results of the gamma distribution resulted in numerous large monthly flow values which rendered the generated streamflows for this distribution unusable. Thus, the normal distribution appeared to preserve the mean and standard deviation of the original streamflows better than the log-normal distribution. Therefore, the 10 sequences of 50 years each generated from a normal distribution are assumed to be representative of developed conditions at the RFP. The average annual water yield of a typical RFP basin with 30 percent imperviousness was about 79.2 ac-ft, based upon the 500 years of monthly (6000 months) generated flows assuming a normal distribution. The standard deviation of the annual runoff was about 34.1 ac-ft. This resulted in a hypothetical range of annual runoff values which varied from 10.1 ac-ft to 175.8 ac-ft over the 500-year simulation period. A summary of the original data and monthly and annual statistics of the generated data are given in Table 4. Hydrologic studies by Wright Water Engineers (DOE, 1991) indicate that the annual runoff from the RFP may be about 108 ac-ft per mi^2 in an average year and about 55 ac-ft per mi^2 in a dry year. From this comparison, it was concluded that the 79.2 ac-ft per mi^2 of annual runoff used in this report is representative of a typical RFP drainage basin.

The monthly surface-water runoff values for the typical RFP drainage basin area of 1.0 mi^2 were adjusted for other drainage basin areas by multiplying the 1.0 mi^2 monthly flows by a factor. This factor was calculated for any other RFP drainage basin area by taking that drainage area to the 0.7574 power as shown in equation (1) above (ASI, 1990e).

Average annual water yield for the Walnut Creek basin at selected locations, based upon 500 years of statistically generated monthly flows is summarized in the table below.

Table 4

Summary of Monthly and Annual Statistics of the Generated Synthetic Streamflow Sequences (6,000 Months [10 Sequences of 50-Years Each] of Generated Values)

(Ac-Ft)

	Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Value
Normal	Mean	4.33	1.22	0.68	0.78	0.91	1.05	2.13	9.14	17.7	19.8	16.0	5.51	79.2
	Std. Dev.	5.48	0.87	0.49	0.56	0.65	0.75	2.54	9.76	16.2	16.8	15.2	4.69	34.1
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	00.0	00.0	00.0	0.00	10.1
	Maximum	27.1	3.49	1.82	2.38	2.71	3.19	10.3	42.1	66.9	79.9	71.6	18.0	176
Log Normal	Mean	2.98	1.35	0.74	0.93	1.08	1.25	2.13	3.77	24.9	21.0	24.2	4.38	88.7
	Std. Dev.	4.34	1.58	0.87	1.06	1.23	1.42	2.26	5.66	53.1	38.3	62.8	4.43	104.
	Minimum	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.19	00.0	00.0	0.00	6.38
	Maximum	36.7	11.5	6.21	8.73	10.3	12.0	14.8	64.8	591.	443.	1590.	40.4	1700.
Original Data 1969-1980	Mean	3.01	1.05	0.58	0.70	0.82	0.93	1.38	4.33	13.8	13.4	14.9	3.64	58.6
	Std. Dev.	7.53	0.85	0.48	0.57	0.66	0.76	3.23	12.8	17.8	20.1	17.1	6.00	47.7
	Minimum	0.00	0.14	0.14	0.09	0.11	0.12	0.00	0.00	00.0	00.0	00.0	0.00	7.61
	Maximum	24.4	2.57	1.43	1.59	2.00	2.29	8.97	44.8	55.2	60.0	42.4	7.33	143.

Estimates of Average Annual Water Yield for Current Conditions in the Walnut Creek Basin Based Upon 500 Years of Monthly Synthetic Flows

STREAM	DRAINAGE AREA (sq mi)	ANNUAL YIELD (ac-ft)
Walnut Ck. @ Great Western Res.	5.5	288
Walnut Creek @ Indiana Street	2.9	178
Walnut Creek @ Pond A-4	0.63	55.8
South Walnut Ck. @ Pond B-5	0.41	40.2

Estimates of average monthly water yield, in ac-ft, for the four Walnut Creek sites previously described is given below, based upon the 6000 months of synthetic flows.

Estimates of Average Monthly Water Yield for Current Conditions in the Walnut Creek Basin Based Upon 6000 Months of Synthetic Flows

(Ac-Ft)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wal. C. @ GWR	15.7	4.4	2.5	2.8	3.3	3.8	7.7	33.3	64.5	72.2	58.0	20.0
Wal. C. @ Ind.	9.7	2.7	1.5	1.7	2.0	2.4	4.8	20.5	39.7	44.5	35.7	12.3
Wal. C. @ A-4	3.0	0.9	0.5	0.6	0.6	0.7	1.5	6.4	12.5	14.0	11.2	3.9
S. Wal. C. @ B-5	2.2	0.6	0.3	0.4	0.5	0.5	1.1	4.6	9.0	10.1	8.1	2.8

Annual and monthly water yields calculated from the generated synthetic sequences are estimates of monthly and annual averages, and are not applicable for predicting water yields for a specific year or a month in a specific year. Also, these are estimates of annual and monthly water yield only for current drainage basin conditions at the RFP. These do not consider potential increased runoff from such factors as irrigation diversions, flood overflows across drainage divides, man-made diversions of runoff, nor do the estimates consider reduced runoff as a result of storage of water in reservoirs and subsequent evaporation.

2.3.2 Woman Creek

Woman Creek also has part of its head waters on the RFP and flows eastward (Figures 1 and 3). Woman Creek discharges to Standley Lake (Figure 1) and, with Walnut Creek, helps form Big Dry Creek. Although Woman Creek is generally ephemeral over its length, baseflow is supplied by seeps, springs, irrigation diversions, and overflows from the South Boulder Diversion Canal.

Prior to July 1973, the area along the south side of the RFP Controlled Area was drained by Woman Creek above USGS gaging station 06720700 which measured runoff from an area of about 2.1 mi^2 (Table 2 and Figure 3). In July 1973, this gaging station was moved upstream from Pond C-2 to a site where the drainage area was about 1.8 mi^2 (Table 2 and Figure 3). The two USGS gaging-station locations on Woman Creek were operated from about August 1972 through October 1975. A summary of measured discharges in Woman Creek at these two stations is given in Table 5.

In about 1980, the runoff from the south side of the RFP Controlled Area was diverted to an off-channel storage facility (Pond C-2) by construction of the South Interceptor Canal (Figure 3). Woman Creek was diverted around Pond C-2 by the Woman Creek Diversion (Figure 3). RFP personnel have measured discharge in Woman Creek at Pond C-1 (drainage area of about 1.7 mi^2 not including the area diverted to Pond C-2). Table 5 summarizes the Woman Creek discharges measured at Pond C-1 for the period September 1986 through October 1990. These discharges include irrigation water diverted by the Kinnear Ditch (Figure 1). Diversions by the Kinnear Ditch are summarized later in this report.

Water-yield estimates for Woman Creek were reported in the Task 4 study (ASI, 1990e) using the same regression-analysis methods described in Section 2.3.1 by equation (1). Long-term average annual estimates of water yield for Woman Creek at various locations are given in the following table for natural-flow conditions.

Table 5

Monthly and Annual Discharges as Selected Locations in the Walnut Creek Basin near Rocky Flats Plant

Summary of Measured Discharge
Woman Creek at Pond C-1[2)]
(Ac-Ft)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1986	--	--	--	--	--	--	--	--	--	--	--	0	--
1987	47.5	66.1	66.9	56.7	65.4	61.9	62.3	48.0	12.1	14.9	4.0	26.8	533
1988	63.8	59.4	66.6	52.4	66.3	63.5	63.5	61.3	42.1	0	0	0	539
1989	4.3	61.0	40.9	64.4	57.2	50.1	13.6	8.0	4.9[2)]	0	0	0	304
1990	0	0	0	45.2	64.7	246	319	197	64.2	61.0	11.6	5.7	1,014
1991	23.9	--	--	--	--	--	--	--	--	--	--	--	--

1) Source: EG&G Rocky Flats, Inc.
2) Partial Month

Summary of Measured Discharge
Woman Creek at USGS Sta. 06720690 and 06720700[1)2)]
(Ac-Ft)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1972	--	--	--	--	--	--	--	--	--	--	2.2	10	--
1973	11	29	26	37	50	67	1,020	709	--	10	8.1	7.4	1,975
1974	5.4	13	17	31	24	23	53	46	26	18	18	18	292
1975	19	--	--	--	--	--	--	--	--	--	--	--	--

1) Source: Herr (1976)
2) Values include water imported to the basin for domestic, industrial and irrigation uses.

Estimates of Long-Term Average Annual Water Yield for Natural-Flow Conditions in the Woman Creek Basin

STREAM	DRAINAGE AREA (mi^2)	ANNUAL YIELD (ac-ft)
Woman Creek @ Indiana Street	2.8	30.5
Woman Creek @ Pond C-1	1.7	20.9

During any 10-year period, the annual water yield would range form zero to approximately four times the long-term average annual water yield shown above.

The monthly distribution of the long-term annual water yield for Woman Creek was estimated similarly to that for Walnut Creek by examining the monthly distribution of annual runoff from several long-term USGS gaging stations. Estimates of the long-term average water yield, in ac-ft, for the two Woman Creek sites is given below based upon equation (1) (ASI, 1990e).

Estimates of Long-Term Monthly Water Yield for Natural-Flow Conditions in the Woman Creek Basin

(Ac-Ft)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
% AY	1	1	1	1	1	4	5	16	24	20	20	6
Wom. C. @ Ind.	0.3	0.3	0.3	0.3	0.3	1.2	1.5	4.9	7.3	6.1	6.2	1.8
Wom. C. @ C-1	0.2	0.2	0.2	0.2	0.2	0.8	1.0	3.3	5.0	4.2	4.3	1.3

Because the part of the Woman Creek drainage basin not diverted into Pond C-2 has not experienced any pronounced land-use change or development, the values estimated for natural-flow conditions also represent the current conditions of the Woman Creek watershed. Annual and monthly water yields

calculated for the Woman Creek drainage basin are estimates of long-term averages and are not applicable for predicting water yields for a specific year or a month within a specific year. Also, these are estimates of annual and monthly water yield only for natural-flow conditions. These do not consider potential increased runoff from such factors as irrigation diversions, flood overflows across drainage divides, man-made diversions of runoff, impervious areas such as buildings and parking lots, nor do the estimates consider reduced runoff as a result of storage of water in reservoirs and subsequent evaporation.

2.4 HYDROLOGY OF BIG DRY CREEK

The origin of Big Dry Creek is delineated immediately downstream from Standley Lake Dam (Figure 1). Walnut Creek flows into Big Dry Creek about 3 mi downstream from Standley Lake. The cities of Broomfield, Westminster, and Northglenn operate wastewater treatment plants (WWTP) in the Big Dry Creek basin (Figure 1). The Broomfield WWTP is located along Big Dry Creek near 124th Avenue. Westminster's WWTP is located at about 132nd Avenue and Big Dry Creek. Northglenn's WWTP is located one mile east of I-25 and along Weld County Baseline Road. This WWTP discharges effluent into the Bull Canal with summer releases into Big Dry Creek for flow augmentation.

Big Dry Creek discharges into the South Platte River upstream from Fort Lupton (Figure 1). The Big Dry Creek drainage basin area at its mouth is about 113 mi^2. The USGS operates a gaging station (06720820 on Figure 1) located just upstream from the 120th Avenue bridge and about 5.2 mi downstream from Standley Lake. The Big Dry Creek drainage-basin area at the USGS gage is about 46 mi^2. This gaging station has been in operation since July 1987. A summary of the monthly and annual measured discharge for the period from August 1987 through September 1989 is given in Table 6. Average annual discharge in Big Dry Creek for the relatively short period of record at USGS gaging station 06720820 has been about 9,420 ac-ft/yr. These discharges are affected by storage diversions, ground-water withdrawals, diversions for irrigation, and return flows from irrigated

Table 6

Monthly and Annual Discharges at USGS Sta 06720820, Big Dry Creek at Westminster, CO (Ac-Ft)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	TOTAL
1987	--	--	--	--	--	--	--	--	--	--	2,220	373	--
1988	612	270	74	61	58	87	142	1,650	3,950	3,280	2,600	452	13,240
1989	95	79	74	74	64	80	91	614	774	1,450	1,810	393	5,590

areas. The available USGS data at the gaging station are not indicative of natural yields from the Big Dry Creek drainage basin. The natural water yield of the Big Dry Creek basin is probably similar to other Front Range watersheds, i.e. relatively low, with water users historically relying upon imported water from Clear Creek, Coal Creek or other trans-basin and trans-mountain diversions. Most of the water entering the Big Dry Creek basin is diverted from Clear Creek through the Croke and Farmers Highline canals, and the Church Ditch. Some water also enters the basin from diversions from Coal Creek through the Last Chance, Kinnear, Upper Church and McKay ditches.

The City of Northglenn has taken periodic flow measurements at four sites other than the USGS gaging station. These four sites include (1) 112th Avenue and Sheridan Boulevard, (2) 132nd Avenue downstream from the Broomfield WWTP, (3) 136th Avenue and Washington Street, downstream from the Westminster WWTP, and (4) Weld County Road 6 downstream from the Northglenn WWTP. These measurements are summarized in Table 7 and generally are for low flows.

2.5 SURFACE-WATER RIGHTS TABULATION AND LOCATION

Part of the water entering the Big Dry Creek basin (Water District 2) is sourced in the Coal Creek basin (Water District 6). Table 8 shows a listing of water rights, obtained from the Colorado State Engineer's office, diverting water from Coal Creek into Water District 2. Table 8 shows the name of the water right, the decreed amount in cfs, the adjudication and appropriation dates of the water right, the administration number of the right and comments related to the water right. The administration number of the water right indicates its seniority relative to other water rights in the basin. The smaller the administration number, the more senior the water right. The most senior water rights on a stream receive water before less senior or junior water rights. During times of water shortages, only the most senior water rights would receive water. Figure 4 is a straight-line diagram of the water rights diverting water from Coal Creek into Water District 2 as well as ditches diverting water within Walnut Creek and Woman Creek.

Table 7

Summary of Measured Discharge at Selected Locations on Big Dry Creek[1)]
(cfs)

Date	112th & Sheridan	132nd Avenue	136th & Washington	Baseline Road
11/12/87	1	2	6	--
12/02/87	1	8	17	16
02/18/88	5	22	14	16
03/22/88	1	8	19	12
04/06/88	1	7	18	15
05/12/88	54	58	--[2)]	--
06/08/88	11	32	2	1
07/21/88	38	55	16	17
08/10/88	29	48	16	19
10/24/88	<1	8	5	26
11/03/88	<1	5	9	17
12/01/88	--	--	4	15
03/22/89	--	7	13	22
04/19/89	--	8	--	9
05/17/89	--	13	6	6
06/28/89	18	19	--	4
07/13/89	29	22	5	--
08/16/89	14	19	--	3
09/20/89	4	9	25	25
10/09/89	28	34	11	--
11/14/89	--	10	5	15

1) Source: Compiled by DOE (1991) from measurements by City of Northglenn.
2) -- Indicates no data available.

Table 8

Water Rights Diverting From Coal Creek Into District 2[1)]

Name	Decreed Amount	Adjudication Date	Approp. Date	Admin. Number	Comments
Last Chance Ditch (3)[2)]	1.30 C[3)]	06/02/1882	5/1/1862	4504.00000	From Eggleston Ditch No.2
Last Chance Ditch (4)[2)]	18.00 C	06/02/1882	6/1/1866	5996.00000	
Last Chance Ditch (5)[2)]	10.78 C	06/02/1882	5/1/1870	7426.00000	
Church Ditch (1)[2)]	18.11 C	06/02/1882	9/20/1870	7568.00000	
Standley Ditch Res.	26.47 A	06/02/1882	5/20/1872	8176.00000	
Standley Res. (10)[2)]	940.00 A	12/19/1900	9/1/1869	11841.07184	
Church Upper Lake	120.00 A	12/19/1900	5/20/1870	11841.07445	
Last Chance Res. 1	45.50 A	12/19/1900	4/1/1872	11841.08127	
Last Chance Res. 2	68.20 A	12/19/1900	4/1/1876	11841.09588	
Smart Res. (6)[2)]	236.60 A	12/19/1900	9/1/1882	11932.00000	
Last Chance Res. 2 Enlg	43.30 A	12/19/1900	9/15/1884	12677.00000	
Last Chance Res. 1 Enlg.	24.10 A	12/19/1900	9/15/1885	13042.00000	
Church Upper Lake 1st Enlg.	443.00 A	12/19/1900	11/1/1891	15280.00000	
Smart Res 1st Enlg.	94.70 A	12/19/1900	9/1/1892	15585.00000	
Great Western Res.	296.00 A	03/13/1907	4/21/1903	20188.19468	
Kinnear Ditch No.2 (2)[2)]	781.00 C	06/21/1926	3/4/1902	20890.19055	
Kinnear Res. 1st Enlg.	49488.00A	06/21/1926	3/4/1902	20890.19055	AKA Stanley
Smart Res. 2nd Enlg.	119.70 A	06/21/1926	10/21/1909	21843.00000	
Great Western Res. 1st Enlg.	1757.00 A	02/09/1943	4/21/1903	27930.19468	
Smart Res. 3rd Enlg.	175.50 A	07/17/1961	4/13/1956	38819.00000	Diligence
Smart Res. 3rd Enlg.	248.39 A	07/17/1961	4/13/1956	38819.00000	Diligence
Smart Res. 3rd Enlg.	58.31 A	07/17/1961	4/13/1956	38819.00000	Part of Cond. Decree
Smart Res. Refill	743.83 A	03/04/1964	6/15/1962	41073.00000	
Smart Res. Refill	131.12 A	03/03/1964	6/15/1962	41073.00000	
Zang (McKay) Ditch	--	--	--	--	Degree Denied March 1913

1) Source: Colorado State Engineer Alpha Listing (complied by DOE, 1991).
2) Numbers in parentheses indicates point of diversion shown on Plate I.
3) A means ac-ft.
C means cfs.

Table 9 shows the listing of water rights, obtained from the Colorado State Engineer's office, diverting water from Walnut Creek and Woman Creek. Table 9 also shows the water rights diverting water from Big Dry Creek. Figure 5 is a straight-line diagram of the water rights diverting water from Big Dry Creek. Figure 6 is a straight-line diagram of the water rights diverting water from the South Platte River between the Denver gaging station and the Kersey gaging station which mark the boundaries of Water District 2 on the South Platte River. The location of Big Dry Creek to downstream South Platte River water rights is shown on Figure 6.

The most senior water rights on Walnut Creek, Woman Creek and Big Dry Creek are those having the lowest administration number, as shown in Table 9. For Woman Creek, the senior water rights are the Kinnear Ditch and Standley Reservoir (# 15895.07184). For Walnut Creek, the senior water right is Great Western Reservoir (# 19468.00000). In Big Dry Creek the senior water rights are the Calkins Ditch (#12418.00000), the German Ditch (#13118.00000), and the Whipple Ditch (#13149.00000).

To help assess the quantities of water imported to the Walnut Creek, Woman Creek, and Big Dry Creek basins, diversion records of the water rights diverting water from Coal Creek into Water District 2 and from Clear Creek into Water District No. 2 were obtained from the Colorado State Engineer's files for those ditches diverting water from these two streams. Table 10 shows the diversion data for the Upper Church Ditch, Kinnear Ditch, McKay Ditch, and the Mower Ditch for water years 1950 through 1988. Based upon these available records, the Upper Church, Kinnear and McKay Ditches diverted an average annual quantity of about 654 ac-ft from Coal Creek across the RFP and into the Big Dry Creek basin. The largest combined annual diversions by the above three ditches was 2,418 ac-ft in 1961. The smallest combined annual diversions by the three ditches was zero in several years. Upper Church Ditch water is stored in Upper Church Lake which is in the Big Dry Creek basin.

Table 9

Water Rights on Walnut, Woman and Big Dry Creeks[1)]

Walnut Creek

NAME	DECREED AMOUNT	ADJUDICATION DATE	APPROP. DATE	ADMIN. NUMBER	COMMENTS
GREAT WESTERN RES. (11)[2)]	1595.74 A[3)]	8/2/1918	4/21/1903	19468.00000	
GREAT WESTERN RES.	1595.74 A	8/2/1918	4/21/1903	19468.00000	

Woman Creek

NAME	DECREED AMOUNT	ADJUDICATION DATE	APPROP. DATE	ADMIN. NUMBER	COMMENTS
KINNEAR DITCH (9)[2)]	40.47 C	8/12/1918	9/1/1869	15895.07184	NOT TO EXCEED 2720 AF ANNUALLY
STANDLEY RES.	940.36 A	8/2/1918	9/1/1869	15895.07184	
MOWER DITCH (7)[2)]	6.60 C	12/21/1972	12/31/1872	44559.08401	USE TO FILL MOWER RESERVOIR
MOWER RES.(8)[2)]	75.00 A	12/31/1972	12/31/1872	44559.08401	

Big Dry Creek

NAME	DECREED AMOUNT	ADJUDICATION DATE	APPROP. DATE	ADMIN. NUMBER	COMMENTS
S. CALKINS DITCH	0.990 C	2/15/1888	12/21/1883	12418.00000	
S. GERMAN DITCH	0.990 C	2/15/1888	11/31/1885	13118.00000	SUFFICIENT FOR 36 ACRES
S. WHIPPLE DITCH	0.990 C	2/15/1888	12/31/1885	13149.00000	
BIG DRY CREEK	32.600 C	10/9/1895	12/15/1889	14594.00000	
S. LITLE CHURCH DITCH	1.000 C	8/2/1918	7/1/1871	15895.07852	TRANSFER TO CHURCH POND #4
CHURCHS LOWER LAKE	135.960 A	8/2/1918	7/1/1871	15895.07852	ALSO DIVERTS FROM DRAW
CALKINS DRY CREEK DITCH	13.000 C	8/2/1918	9/15/1883	15895.12311	LIMIT 1480 AF ANNUALLY
WHIPPLE DITCH	5.000 C	8/2/1918	9/1/1884	15895.12663	LIMIT 300 AF ANNUALLY
GERMAN DITCH	85.000 C	8/2/1918	11/25/1885	15895.13113	NOT TO EXCEED NEEDS OF 1600 ACRES
GERMAN NO. 8 RES.	54.410 A	8/2/1918	9/1/1886	15895.13393	
GERMAN NO. 12 RES.	91.820 A	8/2/1918	9/1/1888	15895.13393	
GERMAN NO. 2 RES.	92.500 A	8/2/1918	9/12/1887	15895.13769	
GERMAN NO. 3 RES.	19.510 A	8/2/1918	9/12/1887	15895.13769	
GERMAN NO. 5 RES.	23.310 A	8/2/1918	9/1/1889	15895.14489	
BIG DRY CREEK DITCH	36.660 C	8/2/1918	12/15/1889	15895.14594	LIMIT 1800 AF ANNUALLY
NORTH STAR RES.	128.970 A	8/2/1918	4/4/1896	16896.00000	

Table 9 - con't.

Water Rights on Walnut, Woman and Big Dry Creeks[1)]

Big Dry Creek

NAME	DECREED AMOUNT	ADJUDICATION DATE	APPROP. DATE	ADMIN. NUMBER	COMMENTS
YOXALL DITCH	16.800 C	8/2/1918	7/27/1896	17010.00000	NOT TO EXCEED NEEDS OF 320 ACRES
GERMAN NO. 7 RES.	6.880 A	8/2/1918	9/1/1898	17776.00000	
GERMAN NO. 4 RES.	36.140 A	8/2/1918	9/1/1902	19236.00000	
GERMAN NO. 11 RES.	9.180 A	8/2/1918	9/1/1904	19967.00000	
GERMAN NO. 6 RES.	22.950 A	8/2/1918	3/17/1906	20529.00000	
GERMAN NO. 9 RES.	18.360 A	8/2/1918	3/17/1906	20529.00000	
HARRY BROWN DITCH	3.300 C	12/31/1970	12/31/1895	43829.16801	
BULL CANAL RES NO. 8	5950.000 A	12/31/1976	5/6/1976	46147.00000	RIGHT TO FILL AND REFILL
JACKSON GATE PIPELINE	0.067 C	12/31/1978	6/1/1978	46903.00000	
JACKSON GATE STORAGE	0.250 A	12/31/1978	6/1/1978	46903.00000	
TROSTEL DITCH	2.000 C	12/31/1980	10/29/1980	47784.00000	
TROSTEL DITCH	1.500 C	12/31/1980	10/29/1980	47784.00000	
IDE LATERAL DITCH #1	56.200 C	12/31/1986	5/22/1986	49815.00000	
IDE STORAGE POND #1	10.000 A	12/31/1986	5/22/1986	49815.00000	
LOWER CHURCH LAKE	242.000 A	12/31/1986	5/22/1986	49815.00000	AKA MANDALAY LAKE

1) Source: Colorado State Engineer Alpha Listing (compiled by DOE, 1991).
2) Numbers in parenthesis indicate point of diversion shown on Plate I.
3) A means ac-ft.
   C means cfs.

Table 10

Colorado State Engineer Ditch Diversion Data for the Upper Church, Kinnear, McKay and Mower Ditches

Water Year[1]	Annual Ditch Diversion (ac-ft) Upper Church Ditch	Kinnear Ditch	McKay (Zang) Ditch	Mower Ditch
1950	166	0	--[4]	--
1951	270	1000	--	--
1952	160	1000	--	--
1953	140	1000	--	--
1954	0	0	--	--
1955	20	20	--	--
1956	0	0	--	--
1957	0	1000	--	--
1958	@[2]	@	--	--
1959	328	1694	0	--
1960	410	1327	0	--
1961	432	1784	202	--
1962	186	1610	0	--
1963	@	@	0	--
1964	0	@	*[3]	--
1965	0	@	*	--
1966	0	0	0	--
1967	0	330	0	--
1968	0	0	0	--
1969	@	@	*	--
1970	0	0	0	--
1971	0	0	0	--
1972	0	0	0	--
1973	0	0	0	--
1974	0	*	*	--
1975	*	*	@	--
1976	0	469	0	--
1977	0	214	0	--
1978	0	271	0	--
1979	*	1327	*	--
1980	0	1190	*	*
1981	0	*	*	*
1982	0	0	*	*
1983	0	*	*	*
1984	*	@	*	*
1985	0	125	*	39.6
1986	0	994	*	*
1987	0	145	*	*
1988	0	817	276	*

1) Colorado State Engineer's Water Year is November 1 through October 31.
2) (@) Records state water used or diverted to storage, but quantity unspecified.
3) (*) No information available.
4) (--) Insufficient data available to make calculation.
Source: Adapted from ASI (1990e).

Coal Creek water diverted through the Kinnear Ditch and the Last Chance Ditch is stored in Standley Lake (Figure 1). The average annual quantity of Coal Creek water diverted to Standley Lake through the Kinnear Ditch, based upon Colorado State Engineer's diversion records for the period 1970 through 1988 as shown in Table 11, was about 400 ac-ft. Based upon the same period of record, the average annual quantity of water diverted to Standley Lake by the Last Chance Ditch was about 310 ac-ft (Table 11).

Water is diverted from Clear Creek and transported to Standley Lake through the Croke Canal, Church Ditch, and Farmer's Highline Canal (Figure 1). According to the Colorado State Engineer's records for the 1970 through 1988 period, an annual average water quantity of approximately 12,000 ac-ft/yr has been diverted to Standley Lake through Croke Canal, and an annual average of approximately 5,200 ac-ft has been diverted to that reservoir through Farmer's Highline Canal as shown in Table 11. Therefore, on an annual basis, an average of approximately 17,200 ac-ft of Clear Creek water has been diverted to Standley Lake during the period 1970 through 1988, based upon interpretation of Colorado State Engineer's records.

For some of the years, the Colorado State Engineer's diversion records are unclear as to the quantity of diverted water stored in Standley Lake and the quantity applied to land as irrigation or used for other purposes. In other instances, for some of the years, no information is available, and in others, records state that water was diverted into one or another ditch, but no quantity is specified. Therefore, the accuracy of the aforementioned annual input quantities from Croke Canal, Farmer's Highline Canal, Church Ditch, Last Chance Ditch, and Kinnear Ditch are judged to be only fair and an additional source of data was sought. In a technical memorandum to the Cities of Thornton and Westminster prepared by Richard P. Arber Associates (1984), Standley Lake inflows from Coal Creek and Clear Creek through the ditches are reported for the years 1981 through 1983. Table 11 compares values of water-inflow to Standley Lake for the years 1981 through 1983 as reported by both the Colorado State Engineer and Richard P. Arber Associates. Because of uncertainties in interpreting the Colorado State Engineer's records, the

Table 11

Imported Water Yield to Standley Lake

Water Year	Imported Water (ac-ft)									
	Last Chance DITCH[1]	Last Chance & Church Ditch[2]	Croke CANAL[1]	Croke Canal[2]	Farmer's Highline Canal[1]	Farmer's Highline Canal[2]	Kinnear Ditch[1]	Kinnear Ditch[2]	Total[1]	Total[2]
1970	0		23,334		5,480		0		28,814	
1971	0		5,451		4,715		0		10,166	
1972	78		18,078		1,994		0		20,150	
1973	0		25,157		6,536		0		31,693	
1974	*[4]		16,049		2,714		*		--[6]	
1975	370		8,596		600		*		--	
1976	109		14,735		0		469		15,313	
1977	203		11,276		0		214		11,693	
1978	284		18,875		123		271		19,553	
1979	609		17,367		595		1,327		19,898	
1980	214		8,690		1,006		1,190		11,000	
1981	342	875	14,611	13,193	841	9,342	*	1,378	--	24,788
1982	0	2,113	15,880	15,263	13,966	23,832	0	2,674	29,846	43,882
1983	961	2,349	8,843	10,926	4,787	11,108	*	6,186	--	30,579
1984	445		2,657		6,411		@[5]		--	
1985	720		6,521		11,283		125		18,649	
1986	660		6,329		20,891		994		28,874	
1987	187		1,684		16,042		145		18,058	
1988	399		8,467		0		817		9,683	
Average[3]	310	1,779	12,000	13,127	5,200	14,760	400	3,412	20,000	33,083

1) Values obtained from Colorado State Engineer records.

2) Values from Richard P. Arber Associates (1984).

3) Averages calculated for the years data were available.

4) (*) No information available.

5) (@) Records state water used or diverted to storage, but quantity unspecified.

6) (--) Insufficient data available to make calculation.

Source: ASI (1990f)

NOTES: Source of water in Croke Canal, and Church Ditch and Farmer's Highline Canal is Clear Creek. Source of water in Last Chance and Kinnear Ditches is Coal Creek.

values reported by Richard P. Arber Associates were judged to be more reliable, but of such short duration that the average values might not be representative of historical diversions.

Sources of water imported to Great Western Reservoir include Clear Creek water, which is diverted through the Church Ditch, and Coal Creek water which is diverted through the McKay (Zang) Ditch (Figure 1). The McKay Ditch flows onto the RFP site, into the McKay Bypass Canal, and into Walnut Creek, which is tributary to Great Western Reservoir. Diversion data from the Colorado State Engineer's files for the period 1950 through 1988 (Table 10) indicate that the McKay Ditch diverted an annual average of about 30 ac-ft. However, all the water was diverted in the years 1962 (202 ac-ft) and 1988 (276 ac-ft) as shown in Table 10.

Since 1970, Colorado State Engineer's diversion records (Table 12) indicate that an annual average quantity of approximately 3,000 ac-ft was diverted to Great Western Reservoir through the Church Ditch. From 1982 through 1989, according to City of Broomfield records, an annual average quantity of approximately 2,000 ac-ft was diverted to Great Western Reservoir through the Church Ditch. For the period between 1982 and 1989, the Colorado State Engineer and City of Broomfield records for the Church Ditch input to Great Western Reservoir differ considerably (Table 12). For example, in 1984, the Colorado State Engineer's records indicate that a volume of 8,486 ac-ft was diverted to storage, whereas City of Broomfield records show that 1,490 ac-ft was received from the Church Ditch. In 1986, 7,065 and 2,632 ac-ft of Clear Creek water was diverted to Great Western Reservoir through the Church Ditch, according to the Colorado State Engineer's the City of Broomfield's records, respectively. Because the Colorado State Engineer's records were sometimes unclear regarding the amount of water diverted, where it was transported, and how it was used, City of Broomfield records are judged to be more accurate.

For most years since 1950, the Colorado State Engineer's diversion records for McKay Ditch input to Great Western Reservoir are missing or incomplete. City of Broomfield records from 1982 through 1989 (Table 12) indicate that an annual average volume of 300 ac-ft of water was imported to Great Western Reservoir through the McKay Ditch. According to City of

Table 12

Water Yield to Great Western Reservoir

Water Year	Water Yield (ac-ft)						
	Church Ditch[1]	Church Ditch[2]	McKay Ditch[1]	McKay Ditch[2]	Walnut Creek[2]	Total[1]	Total[2]
1970	1,148	*[4]	0	*	*	1,148	*
1971	1,292	*	0	*	*	1,292	*
1972	1,372	*	0	*	*	1,372	*
1973	521	*	0	*	*	521	*
1974	1,870	*	*	*	*	--[6]	*
1975	1,364	*	@[5]	*	*	--	*
1976	0	*	0	*	*	0	*
1977	0	*	0	*	*	0	*
1978	0	*	0	*	*	0	*
1979	0	*	*	*	*	--	*
1980	0	*	*	*	*	--	*
1981	397	*	*	*	*	--	*
1982	5,584	2,959	*	156	379	--	3,494
1983	1,110	843	*	413	2,023	--	3,279
1984	8,486	1,490	*	115	830	--	2,435
1985	7,439	1,584	*	170	385	--	2,139
1986	7,065	2,632	*	159	663	--	3,454
1987	3,859	1,183	*	718	1,009	--	2,910
1988	56	2,070	276	641	766	332	3,477
1989	*	3,577	*	0	129	*	3,706
Average[3]	3,000	2,000	--	300	770	--	3,100

1) Values obtained from Colorado State Engineer records.

2) Values from City of Broomfield records.

3) Averages calculated for the years data were available, and rounded to two significant digits.

4) (*) No information available.

5) (@) Records state water used or diverted to storage, but quantity unspecified.

6) (--) Insufficient data available to make calculation.

Source: ASI (1990f).

Broomfield records, an annual average volume of approximately 770 ac-ft was input to Great Western Reservoir from Walnut Creek (Table 12). It is likely that some of this Walnut Creek water was from the STP effluent discharge at the RFP which is trans-basin or trans-mountain water imported to the Walnut Creek basin by water purchases from the DWB. For the period January 1986 through December 1990, the STP effluent was discharged at an annual average volume of about 237 ac-ft. The amount of STP effluent that was released under the RFP NPDES permit into Walnut Creek and flowed downstream into Great Western Reservoir is not known with certainty; however, all of the effluent is judged to have been discharged to Walnut Creek. Because this effluent is from generally trans-mountain water, the stream users in the Walnut Creek and Big Dry Creek basins have no legal right to continued use of STP effluent from the RFP (Holland & Hart, Attorneys at Law, 1990).

2.6 SOUTH PLATTE RIVER CALL ANALYSES

In addition to the physical availability of water at the RFP as defined in Sections 2.3 and 2.4 above, the legal availability of water is also an issue. The legal availability of water at the RFP was assessed by analysis of South Platte River calls from water districts downstream from the RFP. Even if water was diverted or stored at the RFP in the past due to relaxed administration of senior calls, this is not a prescriptive right to continue to divert or store water out of priority. When there is a call from the South Platte River, there is no need to replace water to Big Dry Creek water rights, because these water rights also would be out of priority. Replacement water or augmentation water is defined in this report as the water depletion less periods of no water demand.

Senior water rights on the South Platte River downstream from the confluence with Big Dry Creek may be injured if a Zero-Offsite Water-Discharge Plan were implemented at the RFP. The Colorado State Engineer maintains records of historic calls in Water Division 1, the South Platte River basin. When a senior water right "calls" for water, junior water rights upstream must cease diverting until the senior water right has received its water and the call is removed. Past

administration also has recognized the concept of a "futile" call. A futile call can occur when a release of water would not physically reach senior water right making the call because of channel losses or other losses. The records of historic senior water right priority and the date of the calls by Water District can be used to determine the historic reliability of a given water right. DOE (1991) compiled South Platte River calls on Water District 2 which includes the RFP and the Big Dry Creek basin. The calling priorities for a typical dry year (1963) and a typical average year (1974) are summarized by month in Table 13.

A comparison of Tables 9 and 13 indicates that, in a dry year, the water rights in the South Platte River basin putting calls on upstream junior water rights generally have Administration Numbers lower (that is, more senior) than the most senior water rights in Walnut Creek, Woman Creek and Big Dry Creek during the irrigation season (April through September). Therefore, based upon South Platte River calls, the RFP would have to replace on-site runoff stored out of priority at the percentages shown in Table 13 during a dry year.

In an average year, such as occurred in 1974, fewer calls from the lower South Platte River were evident. A comparison of Tables 9 and 13 in July and August of an average year, the majority of Walnut Creek, Woman Creek and Big Dry Creek water rights would be out of priority. Therefore, based upon South Platte River calls, the RFP would have to replace on-site runoff stored out of priority at the percentages shown in Table 13 for an average year. Because the RFP is junior to all existing downstream water rights, it may have to replace all runoff except that occurring during a large storm event in a wet year. Augmentation or replacement water would have to be provided for surface-water runoff from the RFP that was diverted out of priority. This augmentation or replacement water would not include STP effluent or other historical releases which had imported water as their source. For purposes of this analysis, it was assumed that runoff from the developed basins at the RFP would be subject to administration by the Colorado State Engineer.

Table 13

South Platte River Calls on Water District 2 For Typical Dry and Average Year

District 2 Dry Year (1963) Calls

Month	Range of Priority Calls and Administration Numbers	Number of Days of Calls During Month	Percent of Month Called
April	05-01-1866 to 11-14-1877 5965.00000 to 10180.00000	17	57
May	05-01-1866 to 11-05-1874 5965.00000 to 9075.00000	26	84
June	05-01-1866 to 10-05-1871 5965.00000 to 7948.00000	25	83
July	10-05-1871 to 10-26-1881 7948.00000 to 11622.00000	31	100
August	05-03-1866 to 10-26-1881 5967.00000 to 11622.00000	31	100
September	10-05-1871 7948.00000	19	63
October	10-05-1871 to 05-31-1907 7948.00000 to 21031.00000	8	26

District 2 Average Year (1974) Calls

Month	Range of Priority of Calls and Administration Numbers	Number of Days of Calls During Month	Percent of Month Calls
April	No Calls	0	0
May	10-18-1882 to 05-31-1907 11979.00000 to 21031.00000	23	74
June	10-18-1882 11979.00000	7	23
July	10-20-1880 to 10-21-1890 11251.00000 to 14904.00000	27	87
August	10-18-1882 11979.00000	31	100
September	10-18-1882 to 10-01-1888 11979.00000 to 14154.00000	5	17

Source: Compiled by DOE (1991).

2.7 SURFACE-WATER RIGHTS CONSIDERATIONS FOR ZERO-OFFSITE WATER DISCHARGE

An important water rights issue is the amount of depletion the RFP contributes to the existing stream system. Depletion is calculated as the water used minus the return flow, corrected for any lag time. Depletion to the stream, not water use, determines how much augmentation water or replacement water must be provided.Zero-Offsite Water-Discharge Study Task 17 (ASI, 1991e) and Task 21 (ASI, 1991d) include a description of preferred alternatives for control of STP effluent, surface-water runoff, and ground water at the RFP. The nine preferred alternatives for temporary water storage for three RFP populations of 3,000 and 9,000 personnel and a shutdown population scenario for three types of storage facilities are summarized in Table 14. The three preferred alternatives, depending upon storage facilities, for zero discharge at the RFP are summarized in Table 15. The estimated quantity of replacement or augmentation water for these alternatives is summarized in Table 16.

Analysis of Table 16 indicates that the annual quantity of replacement or augmentation water may range from about 110 ac-ft to 233 ac-ft, based upon South Platte River calls and a dry year such as that which occurred in 1963. Based upon the percentage of the monthly runoff which would have to be released (Table 13), the quantities of replacement or augmentation water (Table 16) would have to be made available to downstream water rights during the months of April through October. Additional releases during the non-irrigation season (November through March) also may occur occasionally, but these quantities of water would not be based upon South Platte River Calls but upon calls from senior water rights in the Big Dry Creek basin. It is unlikely that non-irrigation season releases for downstream water rights would be significant, based upon the South Platte River calls shown in Table 13. The estimated quantities of replacement or augmentation water shown in Table 16 are based upon reservoir operational studies presented in Task 21 (ASI, 1991d) and Task 17 (ASI, 1991e) and include surface-water runoff that would have to be released based upon South Platte River calls as well as an assumed annual quantity of 10 ac-ft of ground water which would be tributary to streams. The reservoir operational

Table 14
Summary of Preferred Alternatives for Temporary Water Storage

GENERALIZED ALTERNATIVE	RFP PERSONNEL	ALT. NOS.	PREFERRED ALTERNATIVE DESCRIPTION	CONSTR. COSTS (Million $)	OM & R COSTS (Million $/Yr)
NEW OFF-CHANNEL RESERVOIR	3,000	0b and 1a	Off-channel storage of STP effluent (114 ac-ft/yr) with 108 ac-ft/yr reuse, off-channel storage of surface-water (125.3 ac-ft/yr) and ground water (10 ac-ft/yr), annual makeup water demand (4.73 ac-ft/yr). STP reservoir = 135 ac-ft, Runoff reservoir = 3200 ac-ft.	8.2	1.3
	9,000	0f and 1d	Off-channel storage of STP effluent (340 ac-ft/yr) with 325 ac-ft/yr reuse, off-channel storage of surface-water (125.3 ac-ft/yr) and ground water (10 ac-ft/yr), annual makeup water demand (140 ac-ft/yr). STP reservoir = 410 ac-ft, Runoff reservoir = 325 ac-ft.	17.5	2.7
	Shutdown	0a and 1j	Off-channel storage of STP effluent (114 ac-ft/yr) with no reuse, off-channel storage of surface-water (125.3 ac-ft/yr) and ground water (10 ac-ft/yr), no makeup water and spray evaporation (246.2 ac-ft/yr). STP reservoir = 1730 ac-ft, Runoff reservoir = 1900 ac-ft.	11.5	1.7
GREAT WESTERN RESERVOIR	3,000	0b and 2h	Off-channel storage of STP effluent (114 ac-ft/yr) with 108 ac-ft/yr reuse, off-channel storage of surface-water (139.8 ac-ft/yr) and ground water (10 ac-ft/yr), annual makeup water demand (4.73 ac-ft/yr). STP reservoir = 135 ac-ft, Diversion channel around Great Western Reservoir.	77.7	11.7
	9,000	0f and 2k	Off-channel storage of STP effluent (340 ac-ft/yr) with 325 ac-ft/yr reuse, off-channel storage of surface-water (139.8 ac-ft/yr) and ground water (10 ac-ft/yr), annual makeup water demand (140 ac-ft/yr) with downstream releases for water rights (111.6 ac-ft/yr). STP reservoir = 410 ac-ft, Diversion channel around Great Western Reservoir.	104.5	15.7
	Shutdown	0a and 2l	Off-channel storage of STP effluent (114 ac-ft/yr) with no reuse, off-channel storage of surface-water (139.8 ac-ft/yr) and ground water (10 ac-ft/yr), no makeup water. STP reservoir = 1730 ac-ft, Diversion channel around Great Western Reservoir.	76.3	11.4
TERMINAL PONDS	3,000	0b and 3c	Off-channel storage of STP effluent (114 ac-ft/yr) with 108 ac-ft/yr reuse, terminal pond storage of surface-water (125.3 ac-ft/yr) and ground water (10 ac-ft/yr), annual makeup water demand (4.73 ac-ft/yr) and downstream releases for water rights (99.8 ac-ft/yr). STP reservoir = 135 ac-ft, Raise Pond A-4 by 31 ft, Pond B-5 by 16 ft and Pond C-2 by 10 ft.	18.6	2.8
	9,000	0f and 3d	Off-channel storage of STP effluent (340 ac-ft/yr) with 325 ac-ft/yr reuse, terminal pond storage of surface-water (125.3 ac-ft/yr) and ground water (10 ac-ft/yr), annual makeup water demand (140 ac-ft/yr). STP reservoir = 410 ac-ft, No increase in pond sizes.	13.9	2.1
	Shutdown	0a and 3f	Off-channel storage of STP effluent (114 ac-ft/yr) with no reuse, terminal pond storage of surface-water (125.3 ac-ft/yr) and ground water (10 ac-ft/yr), no makeup water and downstream releases for water rights (99.8 ac-ft/yr). STP reservoir = 1730 ac-ft, raise Pond A-4 by 17 ft, Pond B-5 by 16 ft and Pond C-2 by 10 ft.	19.6	2.9

Source: ASI (1991d).

Table 15
Summary of Preferred Alternatives to Zero Discharge

STORAGE ALTERNATIVE	ALT. NOS.	PREFERRED ALTERNATIVE DESCRIPTION	CONSTR. COSTS (Million $)	OM & R COSTS (Million $/Yr)
NEW OFF-CHANNEL RESERVOIR	6a	Off-channel storage of STP effluent from 6300 RFP personnel (237 ac-ft/yr), surface-water runoff from 1.9 mi^2 (125.3 ac-ft/yr) with the 100-yr, 72-hr flood (425 ac-ft/yr), and ground water (10 ac-ft/yr) with April-through-October on-site spray evaporation in a lined pond (122.9 to 492.4 ac-ft/yr) (Zero Discharge).	4.5	0.7
GREAT WESTERN RESERVOIR	5b(a)	On-channel GWR storage of STP effluent from 6300 RFP personnel (237 ac-ft/yr), surface-water runoff from 5.5 mi^2 (279.7 ac-ft/yr) with the 100-yr, 72-hr flood (1143 ac-ft/yr), and ground water (10 ac-ft/yr) with on-site irrigation of pasture grass (144 to 576 ac-ft/yr).	80.9	12.1
TERMINAL PONDS	4d(a)	Terminal ponds storage of STP effluent from 6300 RFP personnel (237 ac-ft/yr), surface-water runoff from 1.07, 0.41, and 0.35 mi^2 (81.0, 39.2, and 34.8 ac-ft/yr) with the 100-yr, 72-hr flood (243, 106 and 76 ac-ft/yr) for Ponds A-4, B-5, and C-2 respectively, and ground water (10 ac-ft/yr) with a pipeline (187 to 374 ac-ft/yr) to the Denver Water Department Potable Reuse Plant, or with an irrigation water pipeline (164.6 to 658.3 ac-ft/yr) to the new Denver Airport.	146.0	21.9

Source: ASI (1991e).

Table 16

Estimated Replacement or Augmentation Water Quantity for Various Preferred Alternatives

Alternative A Defined in Table 14 and Table 15	Estimated Quantity of Replacement/ Augmentation Water in Dry Year Based Upon South Platte River Calls[1)2)] (ac-ft)
0b and 1a	110
0f and 1d	110
0a and 1j	110
0b and 2h	122
0f and 2k	122
0a and 2l	122
0b and 3c	133
0f and 3d	133
0a and 3f	133
6a	110
5b(a)	233
4d(a)	133

1) 50-year average from reservoir operational studies. Most years will be lower because a dry-year South Platte River call scenario was used in every year of the 50-year operational study.

2) Includes 10 ac-ft/yr ground water.

studies assumed that the dry year South Platte River calls occurred in every year of the 50-year operational study. The estimated surface-water runoff was calculated using monthly synthetic flows generated as described in Section 2.3 above.

3.0 GROUND WATER

3.1 HYDROGEOLOGIC SETTING

The RFP is located 4 mi east of the Front Range section of the Southern Rocky Mountain province and along the western margin of the Colorado Piedmont section of the Great Plains physiographic province (Spencer, 1961). The RFP is located on a pediment alluvium that dips approximately one degree to the east and is dissected by several small streams that flow eastward with their headwaters either on, or one to two mi west of the RFP.

The stratigraphic section in the vicinity of the RFP extends from Precambrian to the Quaternary. Figure 7 represents the stratigraphic section specific to the RFP. Because of the erosion of a large Laramide monoclinal fold, the sequence of rocks from the Pennsylvanian/Permian Fountain Formation to the late Cretaceous Arapahoe Formation crops out west of the RFP. The strata that crop out at the RFP and directly underlie the RFP are, from oldest to youngest (Figure 7), the Pierre Shale, Fox Hills Sandstone, Laramie Formation, and Arapahoe Formation. This stratigraphic sequence represents a continuous transition from a fluvial depositional facies through a deltaic environment to a marine depositional facies (EG&G Rocky Flats, Inc., 1991). Table 17 is a summary of the formations, thicknesses, and facies that occur in the upper portion of the stratigraphic section present at the RFP. These thickness do not necessarily agree with previously published data by VanSlyke and others (1988c, 1988d) on the Arapahoe and Laramie-Fox Hills aquifers. Following are descriptions of each of the formations in Table 17.

Recent preliminary information from EG&G (J. W. Langman, Jr., personal communication) indicates that the previous geologic characteristics of the bedrock aquifers at the RFP is being revised. It appears that units underlying the RFP which were previously identified as the Arapahoe Formation actually may be part of the Laramie Formation. Because a new geologic characterization has not yet been completed at the RFP, this report uses existing published

Table 17

Summary of Formations at the RFP

Formation	Thickness (ft)	Facies
Rocky Flats Alluvium	10 - 100	Alluvial Fan
Lower Arapahoe Formation	250	Fluvial (meanders at top, braided at base)
Laramie Formation	692	Deltaic (Distributary and paludal)
Fox Hills Sandstone	75	Delta - Front
Pierre Shale	>8,000	Marine

Source: EG&G, Rocky Flats, Inc. (1991).

information and data related to the bedrock aquifers. Additionally, the geologic characteristics at the RFP compiled by EG&G Rocky Flats, Inc (1990, 1991) may vary from extrapolations or interplations taken from USGS publications. Generally, the EG&G data are more reliable because they represent on-site investigations, whereas, the USGS data are from wells outside the RFP boundary.

3.2 HYDROLOGY OF THE BEDROCK AQUIFERS

The bedrock aquifers at the RFP include the Pierre Shale, Laramie Formation-Fox Hills Sandstone, and the Arapahoe Formation. The Laramie-Fox Hills and Arapahoe are known to yield moderate amounts of water to wells in the Denver basin. The Pierre Shale is not considered to be an aquifer.

3.2.1 Pierre Shale

The Pierre Shale is over 8,000 ft thick and is predominantly a medium to dark gray, non-calcareous montmorillonite shale. It contains forminifera and *Baculites clinolobatus*, an ammonite, indicating that the Pierre Shale was deposited in a marine environment. The contact between the Pierre Shale and the Fox Hills Sandstone is complex because it represents the transition between marine and continental rocks. Figure 8 shows the approximate contact between the Pierre Shale and the overlying Fox Hills Sandstone on the RFP. No water wells are known to be completed in or penetrate the Pierre Shale in the vicinity of the RFP.

3.2.2 Laramie Formation-Fox Hills Sandstone

The Fox Hills sandstone is approximately 75 ft thick and is a grayish-orange to light gray calcareous, fine grained, subrounded, friable, glauconitic, felspathic sandstone with thin beds of siltstone and claystone. Weimer (1976) interpreted the Fox Hills delta-front sandstone that exists as a separate facies with the underlying Pierre Shale and the overlying Laramie Formation.

Figure 8 shows the approximate location of the geologic contact between the Pierre Shale and the Fox Hills sandstone as well as the approximate location of the geologic contact between the Fox Hills Sandstone and the Laramie Formation at the RFP (Spencer, 1961; Van Horn, 1972).

The Laramie Formation is about 700 ft thick and is composed of a lower sandstone/coal interval and an upper claystone interval. The sandstones are light to medium gray, fine to coarse grained, poorly to moderately sorted, subangular, silty, quartzitic, and contain grains of black chert, clay mica, and carbonaceous material (Van Horn, 1957, 1972; Weimer, 1976). The claystones are kaolinitic and are light to medium gray with lesser amounts of dark gray to black carbonaceous claystone (Weimer, 1976).

The estimated water in storage beneath the RFP in the Laramie-Fox Hills aquifer was estimated by EG&G Rocky Flats, Inc. (1991). Table 18 shows the estimated quantity of water stored in the Laramie-Fox Hills aquifer beneath the RFP plant boundary as shown on Figure 8. The average thickness of the Laramie-Fox Hills aquifer was estimated from isopach maps given by VanSlyke and others (1988d). The average saturated thickness and porosity of the Laramie-Fox Hills aquifer at the RFP were estimated by EG&G Rocky Flats, Inc. (1991). Approximately 228,600 ac-ft of water is estimated to be in storage in the Laramie-Fox Hills aquifer beneath the RFP, assuming an area of 6350 ac, a saturated thickness of 120 ft and a porosity of 30 percent.

The Colorado State Engineer will permit the overlying landowners, or those with control of the land surface overlying non-tributary ground water to beneficially use the ground water at a rate which would deplete the resource in 100 years, or a withdrawal rate of one percent of the non-tributary ground water per year. According to interpretation of the Colorado State Engineer's maps of the Laramie-Fox Hills Aquifer at the RFP (VanSlyke and others, 1988d), all the Laramie-Fox Hills aquifer underlying the RFP is considered by the Colorado State Engineer to be non-tributary. Withdrawal in excess of one percent per year is allowed pursuant to a "banking provision" as long as the total volume of water withdrawn does not exceed the product of the number of years since the date of issuance of the appropriate well permit or the date of

Table 18

Estimated Ground Water in Storage Beneath the RFP

Aquifer	Area (ac)	Average Thickness (ft)	Average Saturated Thickness (ft)	Porosity[1] (%)	Water in Storage (ac-ft)
Alluvium and Valley Fill	6,470	--[2]	10[3]	30	19,400
Lower Arapahoe Formation	4,970	35[4]	15	30	22,400
Laramie-Fox Hills	6,350	200	120	30	228,600
TOTAL					270,400

1) Assumed value based upon data presented by Robson (1987).
2) Not estimated.
3) Estimated from the difference between alluvial and valley fill groundwater elevation (and bedrock elevation over RFP site).
4) Thickness of all Arapahoe Formation sandstones and siltstones. Does not include claystone (which is assumed to have no significant water).

Modified From: EG&G Rocky Flats, Inc. (1991).

determination of the right to this ground water by the Water Court, whichever comes first, and the allowed average annual amount of withdrawal (Holland & Hart, Attorney of Law, 1990).

The amount of non-tributary ground water legally recoverable from the Laramie-Fox Hills aquifer underlying the RFP can be calculated, based upon the average saturated thickness of the aquifer (estimated to be about 120 ft), the specific yield (presumed by the Colorado State Engineer to be 15 percent), and the surface acreage overlying RFP the non-tributary area (measured from maps to be about 6,350 ac). Therefore, the estimated non-tributary water legally recoverable from the Laramie-Fox Hills aquifer underlying the RFP is about 114,300 ac-ft. Annual non-tributary withdrawals may be made over a 100-year period at a rate of about 1,140 ac-ft/yr (about 700 gpm). This non-tributary ground water could be pumped to satisfy replacement or augmentation water for the zero-discharge plan.

The potential for recovery of this water is assessed in Task 29 (ASI. 1991g). Only one well is known to be drilled in the Laramie-Fox Hills aquifer at the RFP (Figure 8). As many as 20 wells are estimated to be completed in the Laramie-Fox Hills downgradient (assumed to be generally north and east) from the RFP as shown Appendix A.

3.2.3 Arapahoe Formation

The upper Arapahoe Formation is eroded away at the RFP. The lower Arapahoe Formation is about 250 ft thick in the central part of the RFP and consists mainly of claystones. However, it also contains at least six mappable sandstone intervals. These sandstone intervals vary in thickness from 0 ft to over 27 ft, and have vertical separations ranging from 2 ft to nearly 100 ft (Figure 7, Table 17). Because the sandstone intervals are fluvial (EG&G Rocky Flats, Inc., 1990), the sandstone channels are not present beneath all of the RFP. Generally, the Arapahoe sandstones that subcrop below the base of the alluvium, colluvium, and valley fill are oxidized and are pale orange, yellowish-gray, and dark yellowish-orange. The sandstones that are not in the weathered zone are light gray and olive gray. Most of the sandstones are very fine to

medium grained (d_{50} = 0.06 mm to 0.09 mm), moderately sorted, and subangular to subrounded, silty, clayey, and quartzitic, with trough and planar cross-stratification. The claystones and silty claystones in the Arapahoe Formation are light to medium olive-gray and occasionally olive-black with some dark yellowish-orange claystones in the weathered intervals near the base of the alluvium.

The Colorado State Engineer (VanSlyke and others, 1988c) has estimated the limits of the lower Arapahoe Formation in the vicinity of the RFP. The predominant water-yielding strata of the lower Arapahoe Formation are the saturated sandstones and siltstones. The clay-shale interbed units are generally assumed to have little water-yielding capabilities, even though large amounts of water may be stored within them. The Colorado State Engineer's maps do not include the clay-shale units as part of the saturated thickness of the Arapahoe Formation in the Denver basin. Figure 8 shows the approximate location of the base of the lower Arapahoe Formation at the RFP based upon interpretation of the Colorado State Engineer's maps. The lower Arapahoe Formation has been determined by the Colorado State Engineer to be non-tributary to streams. To the east of the RFP is the upper Arapahoe Formation (VanSlyke and others, 1988c).

The estimated water in storage beneath the RFP in lower Arapahoe Formation was estimated by EG&G Rocky Flats, Inc. (1991). Table 18 shows the estimated quantity of water stored in the areal extent of the lower Arapahoe Formation beneath the RFP plant boundary as shown on Figure 8. The average saturated thickness of the lower Arapahoe Formation was estimated from three on-site wells which penetrate the Arapahoe Formation (Figure 3). Information collected at these wells indicate that only the basal sandstone of the lower Arapahoe Formation is saturated and has a thickness ranging from 0 to 30 ft. A saturated thickness of 15 ft was used for this study. The porosity of 30 percent was also assumed. The areal extent of 4,970 acres of Arapahoe Formation was measured from Figure 8 based upon aquifer limits taken from VanSlyke and others (1988c). The estimated water in storage in the lower Arapahoe Formation beneath the RFP is about 22,400 ac-ft. Recent preliminary information from EG&G (J. W. Langman, Jr., personal communication) indicates that the basal Arapahoe Formation sandstone may be part of

the Laramie Formation at the RFP. Until this potential inconsistency is resolved, this report will use the existing EG&G, USGS, and Colorado State Engineer interpretation of the extent of the Arapahoe Formation at the RFP.

According to the Colorado State Engineer (VanSlyke and others, 1988c), the water in the lower Arapahoe Formation beneath the RFP is non-tributary. The amount of legally recoverable non-tributary Arapahoe Formation water underlying the RFP can be calculated based upon the average saturated thickness of the aquifer (estimated to be about 15 ft), the specific yield (presumed by the Colorado State Engineer to be 17 percent), and the surface acreage overlying the non-tributary RFP area (measured from maps to be about 4,970 ac). Therefore, the estimated legally recoverable non-tributary water in the Arapahoe Formation aquifer underlying the RFP is about 12,700 ac-ft. Annual non-tributary withdrawals of this water may be made over a 100-year period at a rate of about 127 ac-ft/yr (about 80 gpm). This non-tributary ground water could be used to satisfy replacement or augmentation water for the zero-discharge plan.

The potential recovery of this non-tributary water is assessed in Task 29 (ASI, 1991i). In addition to three on-site wells which penetrate the lower Arapahoe Formation (Figure 8), it is estimated that as many as 70 wells are completed in the lower Arapahoe Formation downgradient (assumed to be generally north and east) from the RFP as shown in Appendix A.

3.3 HYDROLOGY OF THE ALLUVIAL AQUIFER

The Rocky Flats Alluvium (Nebraskan or Aftonian in age) (Scott, 1975) is composed of light brown to dark yellowish-orange, grayish-orange to dark gray, poorly sorted, angular to subrounded, coarse gravel, coarse sand, and gravely clay with varying amounts of caliche. It ranges in thickness from 0 ft to over 98 ft at the RFP and occurs about 250 ft to 380 ft above modern stream channels (Scott, 1975) (Figure 7, Table 17).

The saturated thickness of alluvial and valley fill materials was estimated at the RFP by subtracting the elevation of the top of bedrock from the elevation of the water table in all of the alluvial and valley fill wells. The resulting 10-ft difference (saturated thickness) is shown in Table 18 (EG&G Rocky Flats, Inc., 1991). The total average thickness of the alluvial and valley fill materials at the RFP was not estimated. An assumed porosity of 30 percent for the alluvium and valley fill, and an areal extent of 6,470 ac, give a volume of water in storage in the alluvium and valley fill at the RFP of about 19,400 ac-ft. All of the water in storage in the alluvium and valley fill materials at the RFP is considered by the Colorado State Engineer to be tributary to streams in the area. Therefore, any diversion of water from this aquifer could constitute an out-of-priority diversion subject to the same administration as diversion of water from a stream. It is estimated that up to 10 wells are completed in the alluvial and valley fill aquifers downgradient (assumed to be generally north and east) from the RFP as shown in Appendix A.

3.4 GROUND-WATER RIGHTS TABULATION AND LOCATION

Based upon well permit tabulations of the Colorado State Engineer, there are over 230 registered wells within 2 miles of the RFP boundary. The locations of these registered wells are shown on Plate I and summarized in Appendix A, Table A-1. The well tabulation in Table A-1 includes the well reference number shown on Plate I, well permit number, well location to the nearest 40 ac, well water use as shown on the well permit, well depth, water level, well yield, name of registered owner on the permit, and the date the well was constructed. It should be noted that data tabulated by the Colorado State Engineer may sometimes be in error, especially relative to the well location. Therefore, ASI attempted to field-verify the wells listed in Table A-1 and shown on Plate I.

Field verification was done by trying to locate in the field as many of the wells as possible. Table A-2 summarizes the results of field checking the well locations shown on Plate I. Of the over 230 wells shown on Plate I and listed in Table A-1, only about 32 wells could be positively identified (Table A-2) and several of these identifications were questionable. However, just

because no current well-head evidence could be identified at a given location does not mean that the well permits shown in Table A-1 have not been exercised. Further analysis of the listing of wells in Table A-2 indicates that residences or animal-watering facilities, several instances, existed in the general area of the well locations shown on Plate I. If these developed areas are used as indicators of the presence of a well, then about 190 of the over 230 well permits may have been exercised and appear to be active. The remaining 40 well permits have either never been exercised, had location errors on the well permits, or could not be identified using the field techniques.

A preliminary analysis of the aquifer in which the wells shown in Table A-1 are completed was done using the reported depth of the well only. This analysis is subject to errors in the reported well depth and uncertainty in the geology of the local area. This preliminary analysis indicated that about 12 wells are completed in the alluvial and valley fill materials, about 70 wells are completed in Arapahoe Formation, and about 24 wells are completed in the Laramie-Fox Hills aquifer. The remaining 84 wells have unknown completions or are upgradient (assumed to be generally west and south) of the RFP as indicated in Table A-1.

3.5 GROUND-WATER RIGHTS CONSIDERATIONS FOR ZERO-OFFSITE WATER DISCHARGE

Of the 12 wells assumed to be completed in the alluvial and valley fill materials, about 10 are considered to be downgradient (generally north or east) of the RFP. About 70 of the Arapahoe Formation wells are downgradient, and about 24 of the Laramie-Fox Hills aquifer wells are downgradient from the RFP. The wells completed in the Arapahoe and Laramie-Fox Hills aquifers may not be legally impacted by pumping of non-tributary water from these aquifers at the RFP. Interpretation of the Colorado State Engineer's administration of non-tributary ground water in the Denver basin indicates that, if potentiometric surfaces drop due non-tributary ground-water pumping, all those using the aquifer share in the piezometric surface drop. Therefore, it

is not anticipated that water pumped by the RFP from non-tributary ground water sources would cause depletions or injury to downgradient or downstream water rights.

The downgradient alluvial wells could be impacted if water is diverted out of priority as a result of zero-discharge activities. Water for these wells would have to be replaced or augmented under Colorado Statutes. The amount of alluvial water which may have to be replaced at the RFP will be identified in the results of Task 26 (ASI, 1991h). Because this study is not yet completed, an unknown quantity of water may be involved. For purposes of analysis, it has been assumed that if all alluvial ground-water flow were cut off at the RFP, the average annual amount of water replacement would be about 10 ac-ft per year (DOE, 1991).

4.0 SUMMARY AND CONCLUSIONS

This surface-water and ground-water rights study has assessed the hydrologic characteristics of streams and aquifers in the vicinity of the RFP. The purpose of this assessment was to give a preliminary analysis of potential injury to both surface-water and ground-water rights downstream from the RFP for various preferred alternatives related to zero-offsite water discharge from the RFP and for alternatives to zero discharge from the RFP such as on-site irrigation of pasture grass, off-site irrigation of landscaping at the new Denver airport, or off-site water reuse at the Denver Water Department Potable Reuse Plant.

The RFP purchases about 395 ac-ft/yr of trans-mountain and trans-basin water from the Denver Water Board. Previous legal opinions (Holland & Hart, Attorney of Law, 1990; Holme, Roberts and Owen, Attorney of Law, 1990), and correspondance between DOE and the DWB (DOE, 1979) indicates that this water may not have to be returned to the South Platte River basin to satisfy downstream water rights. The DWB, however, may require return of a all or part of the purchased water, but the existing DOE contract with the Denver Water Board does not address this return flow. A possible worst case would be that the RFP would have to replace historical STP effluent discharges which have averaged about 237 ac-ft/yr during the 1986 through 1990 period.

Surface-water runoff from that part of the RFP where future runoff may be controlled (areas varying from 1.9 mi^2 to 5.5 mi^2), could have an estimated average annual runoff of about 125 ac-ft and 280 ac-ft, respectively (ASI, 1991b). Because all or part of this runoff would be diverted out of priority, it would require replacement or augmentation, at least during the months of April through October, during all years. Assuming a dry year with replacement or augmentation water governed by South Platte River calls, the average annual quantity of water which must be replaced or augmented by the RFP may range from about 110 ac-ft to 233 ac-ft (Table 16) depending upon the selected zero-discharge alternative. The average annual quantity of ground water which may have to be replaced or augmented is unknown at this time, but has

been assumed to be on the order of 10 ac-ft (DOE, 1991). Thus, the total estimated average annual quantity of replacement or augmentation water for various preferred zero-discharge options and alternatives to zero discharge may vary from 120 ac-ft to 480u ac-ft. This estimate include the average annual STP effluent and the average annual ground-water quantity.

Non-tributary ground water beneath the RFP could be used to provide replacement or augmentation water to downstream water rights. The estimated legally recoverable quantity of non-tributary ground water in the Arapahoe and Larimie-Fox Hills aquifers underlying the RFP is about 127,000 ac-ft under current applicable resource-management guidelines. The Colorado State Engineer would permit this water to be extracted at a rate of about 780 gpm over a 100-year period. However, not all of this water could easily or economically be extracted.

Additional sources of water which could be used as replacement or augmentation water for downstream senior water rights would vary, depending upon the zero-discharge alternative implemented. These sources may include leasing surface water from rights in the Clear Creek basin or South Platte River basin from an existing water-right holder, such as Coors (Neil Jaquet, personal communication). Such a lease agreement should include the quantity, timing and quality of the water which would be released over a specified duration. If DOE purchases Great Western Reservoir as indicated in the Rocky Flats Surface Water Management Plan (DOE,1991) the water rights for this Reservoir also should would be purchased. These water rights include storage of 1,595.74 ac-ft annually with a storage capacity of 3,250 ac-ft. The City of Broomfield also owns nearly 2000 inches of Church Ditch water having an annual yield of between 2,000 ac-ft (City of Broomfield records) and 3,000 ac-ft (Colorado State Engineer's records). This Church Ditch water right should be included in the Great Western Reservoir purchase. The Great Western Reservoir and Church Ditch water rights could be used as augmentation or replacement water if water-quality considerations are addressed. If DOE purchases Great Western Reservoir, the Colorado Department of Health may claim that the quality of water in the reservoir should meet or exceed that rather stringent numeric stream standards currently in effect on Walnut Creek.

5.0 ACKNOWLEDGMENTS

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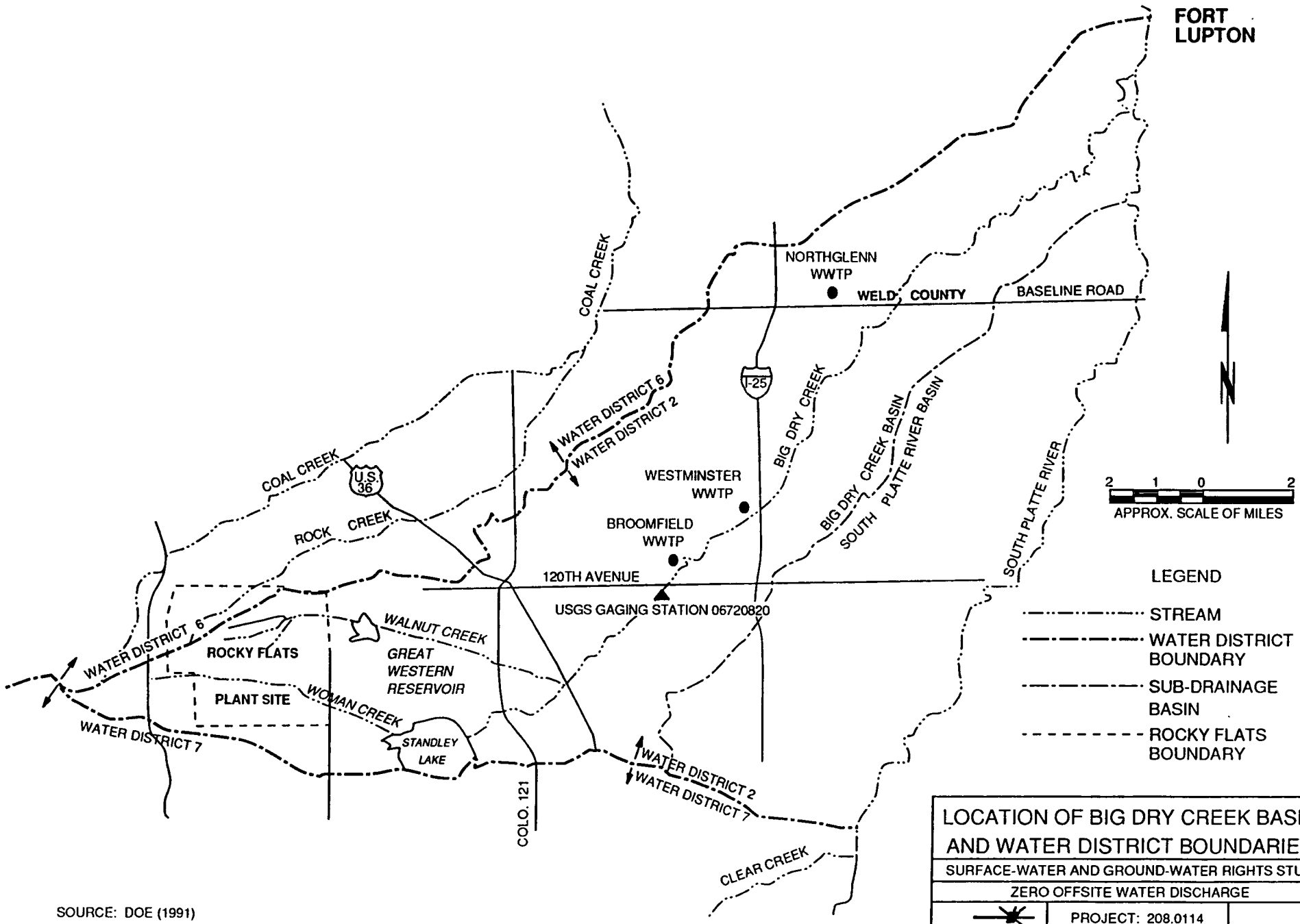
FIGURES



SOURCE: DOE (1991)

LOCATION OF BIG DRY CREEK BASIN AND WATER DISTRICT BOUNDARIES

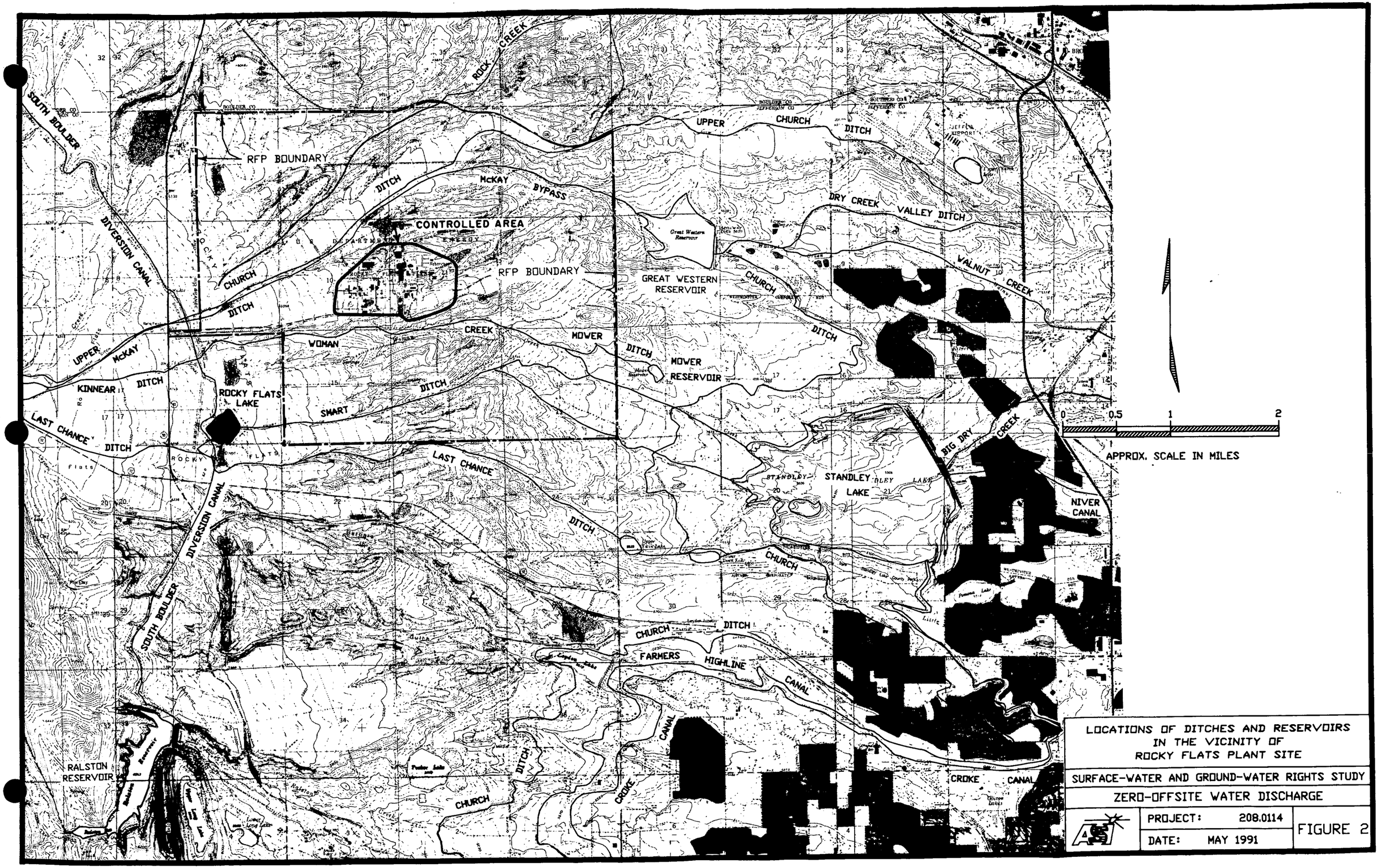
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: APR 1991

FIGURE 1



LOCATIONS OF DITCHES AND RESERVOIRS IN THE VICINITY OF ROCKY FLATS PLANT SITE

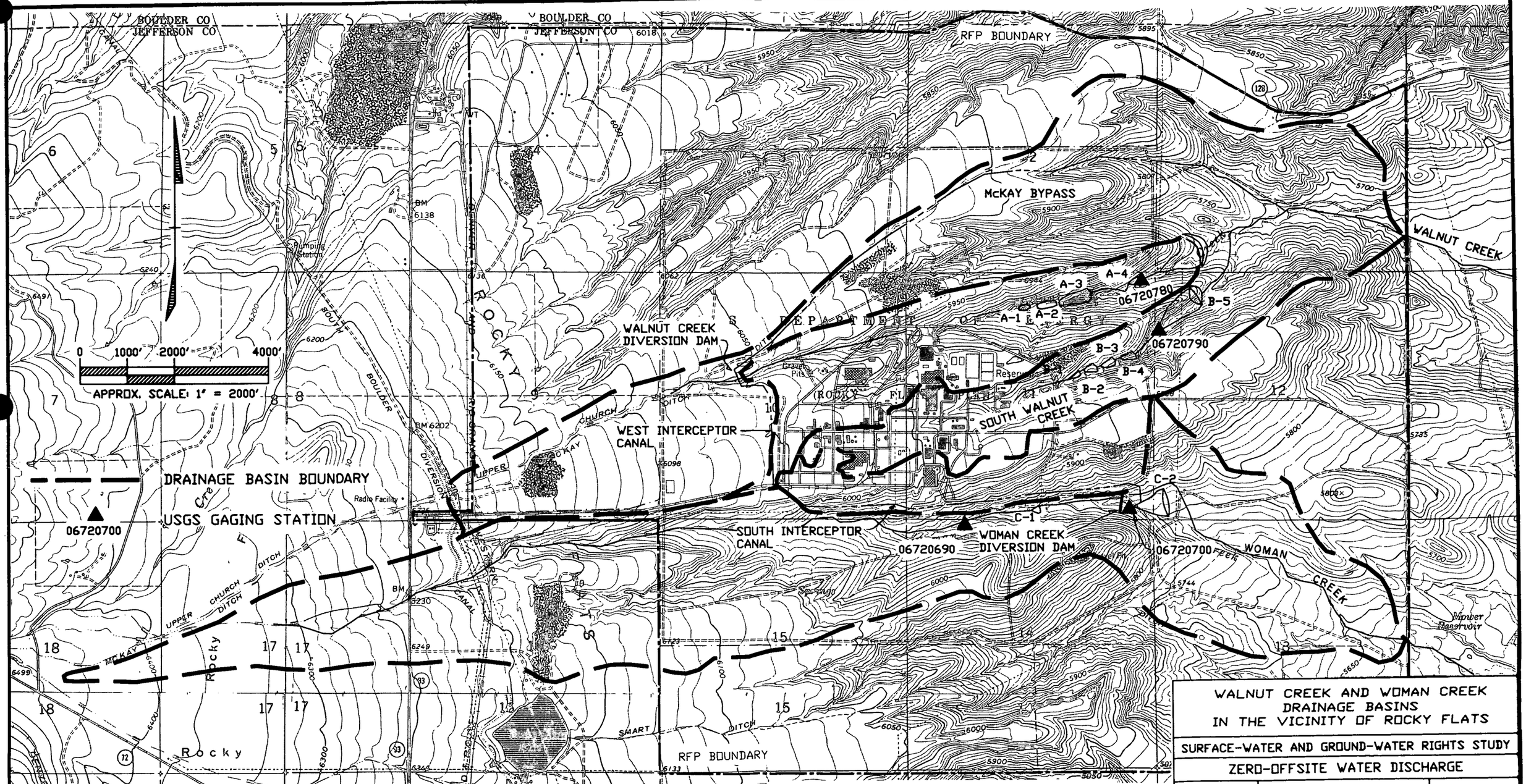
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO-OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: MAY 1991

FIGURE 2



WALNUT CREEK AND WOMAN CREEK
DRAINAGE BASINS
IN THE VICINITY OF ROCKY FLATS

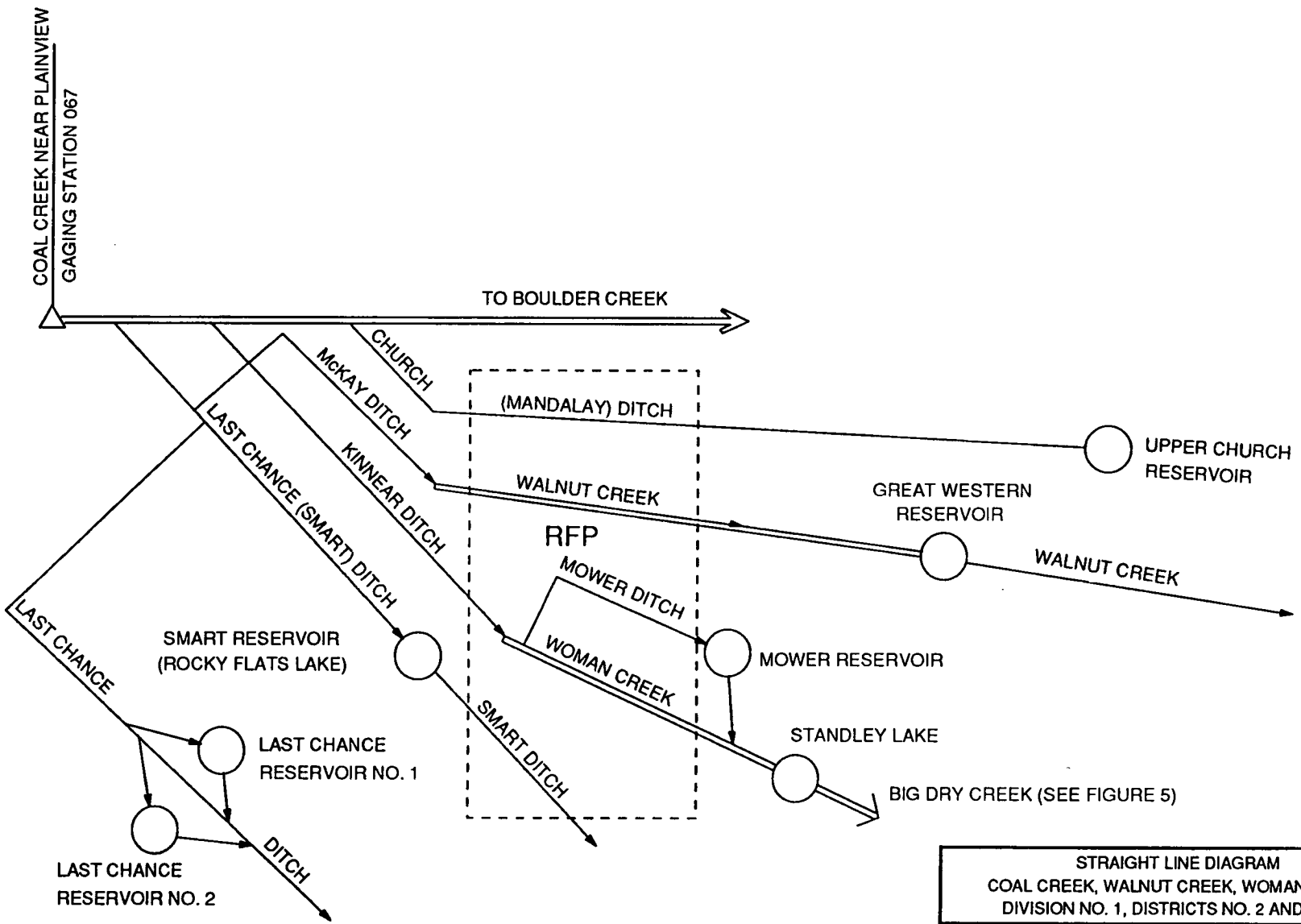
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO-OFFSITE WATER DISCHARGE

PROJECT: 208.0114

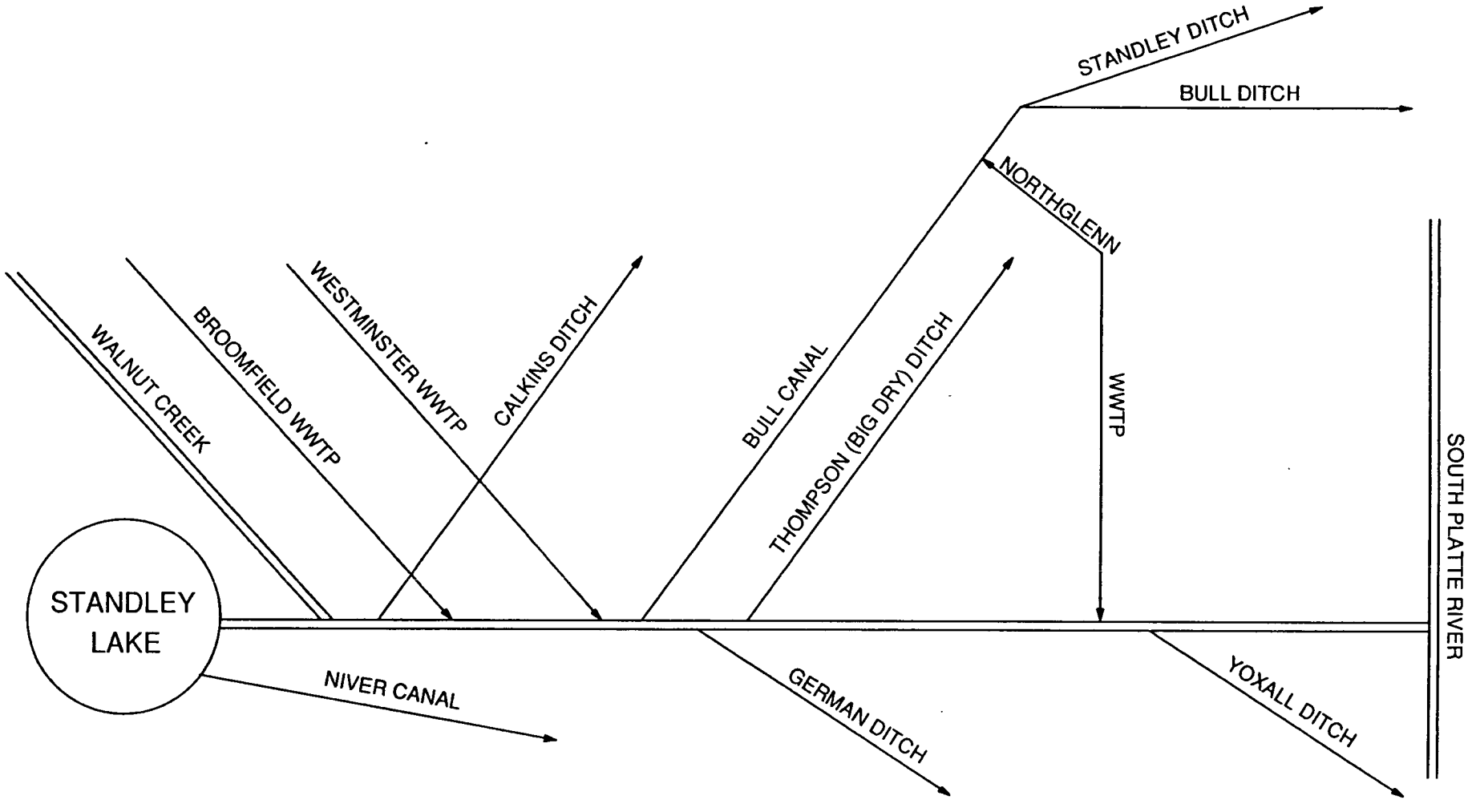
DATE: MAY 1991

FIGURE 3



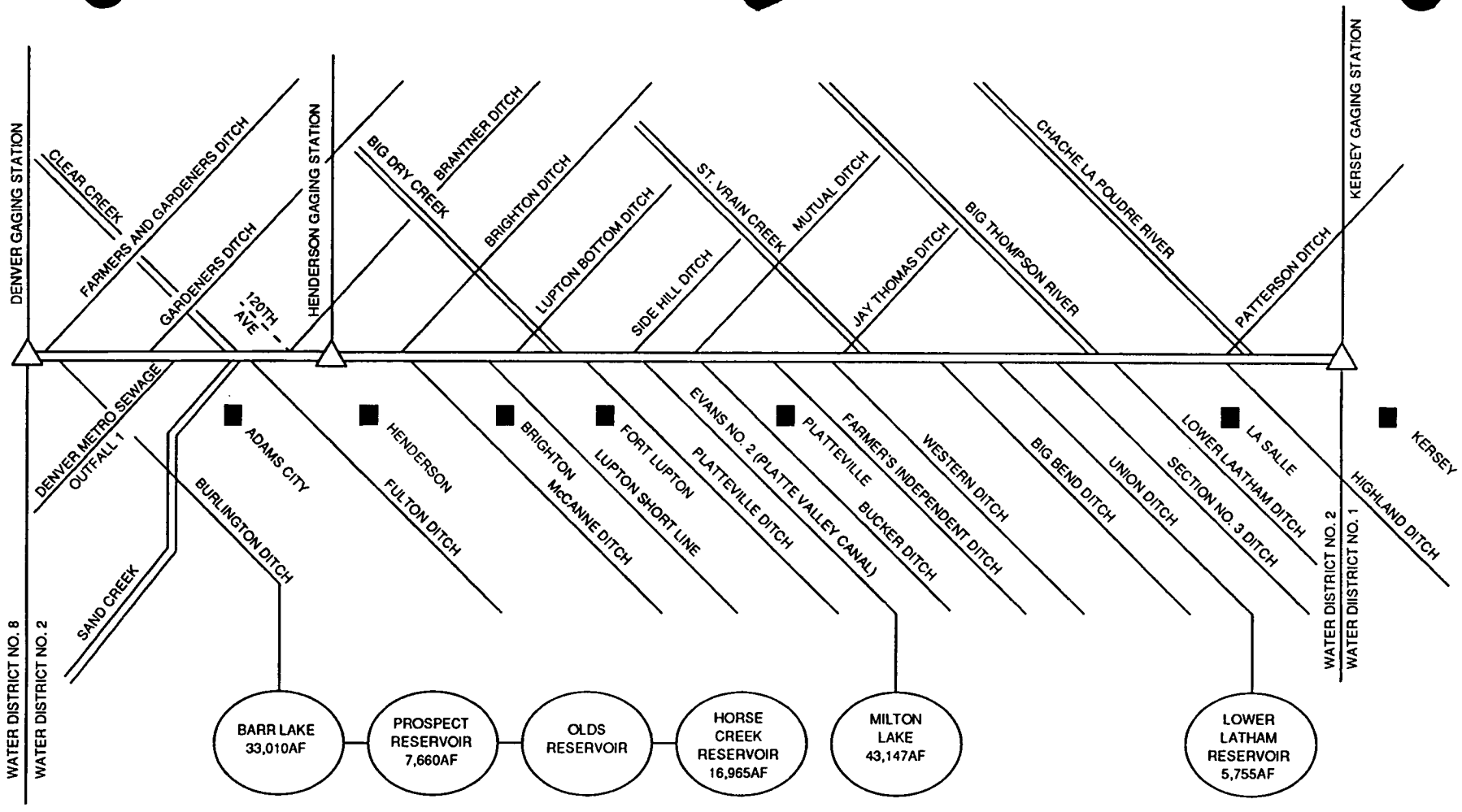
SOURCE: DOE, 1991

STRAIGHT LINE DIAGRAM COAL CREEK, WALNUT CREEK, WOMAN CREEK DIVISION NO. 1, DISTRICTS NO. 2 AND NO. 6		
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY		
ZERO OFFSITE WATER DISCHARGE		
	PROJECT: 208.0114	FIGURE 4
	DATE: MAY 1991	



SOURCE: DOE, 1991

STRAIGHT LINE DIAGRAM BIG DRY CREEK DIVISION NO. 1, DISTRICT NO. 2		
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY		
ZERO OFFSITE WATER DISCHARGE		
	PROJECT: 208.0114	FIGURE 5
	DATE: MAY 1991	



SOURCE: DOE, 1991

STRAIGHT LINE DIAGRAM
SOUTH PLATTE RIVER
DIVISION NO. 1, DISTRICT NO. 2

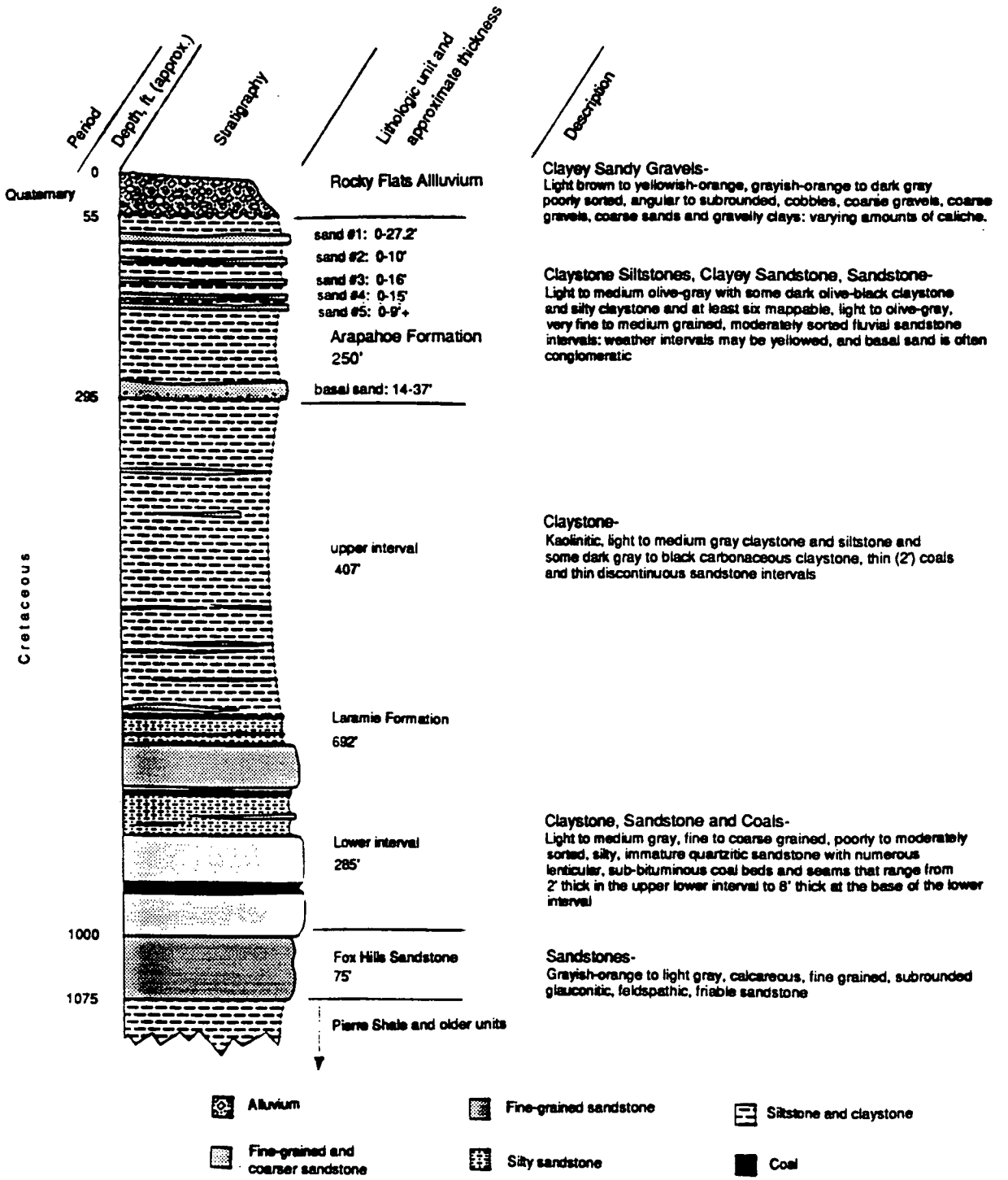
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: MAY 1991

FIGURE 6



GENERALIZED STRATIGRAPHIC SECTION
ROCKY FLATS PLANT

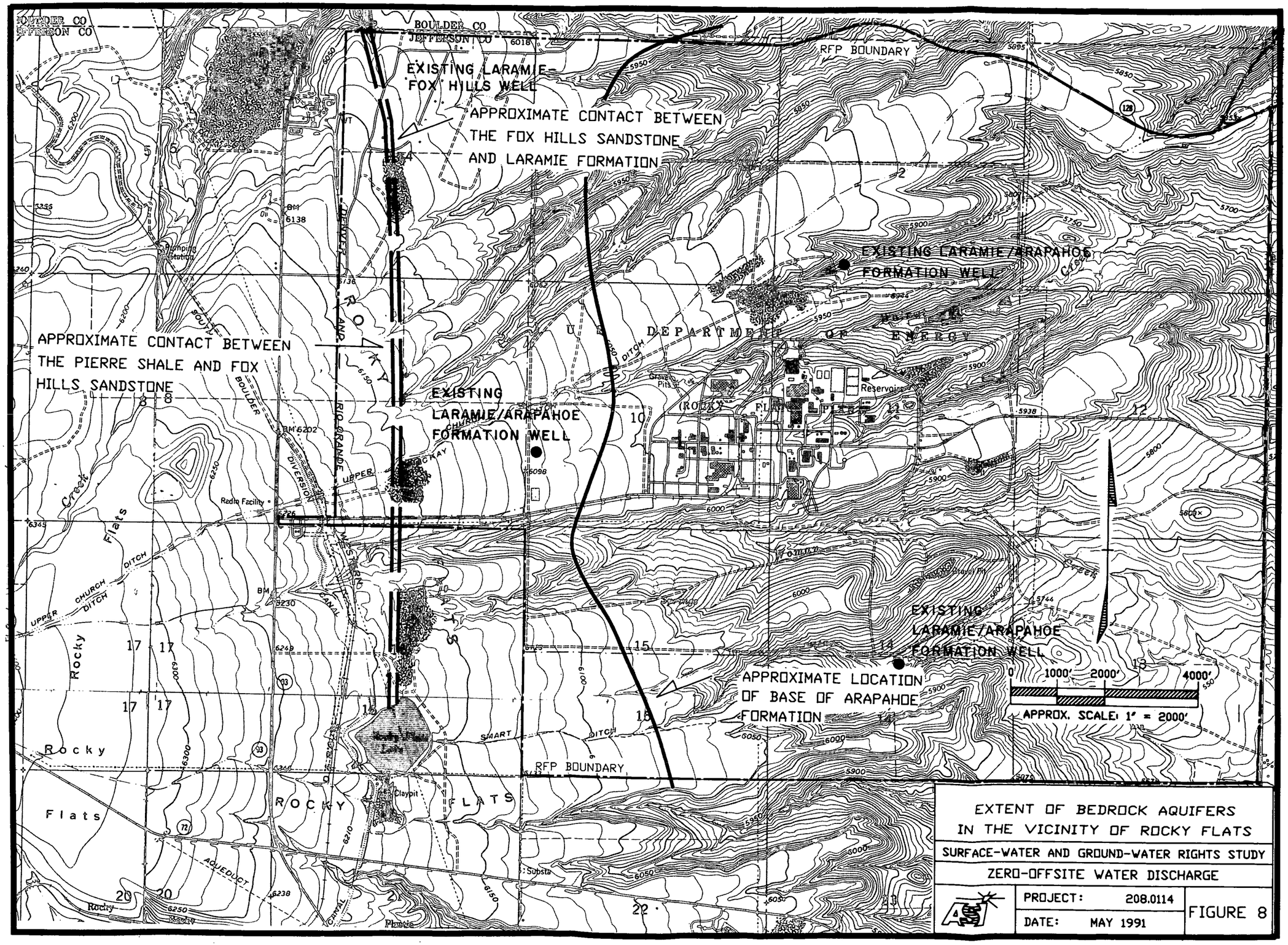
SURFACE-WATER AND GROUND-WATER RIGHTS

ZERO OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: MAY 1991

FIGURE 7



EXTENT OF BEDROCK AQUIFERS IN THE VICINITY OF ROCKY FLATS

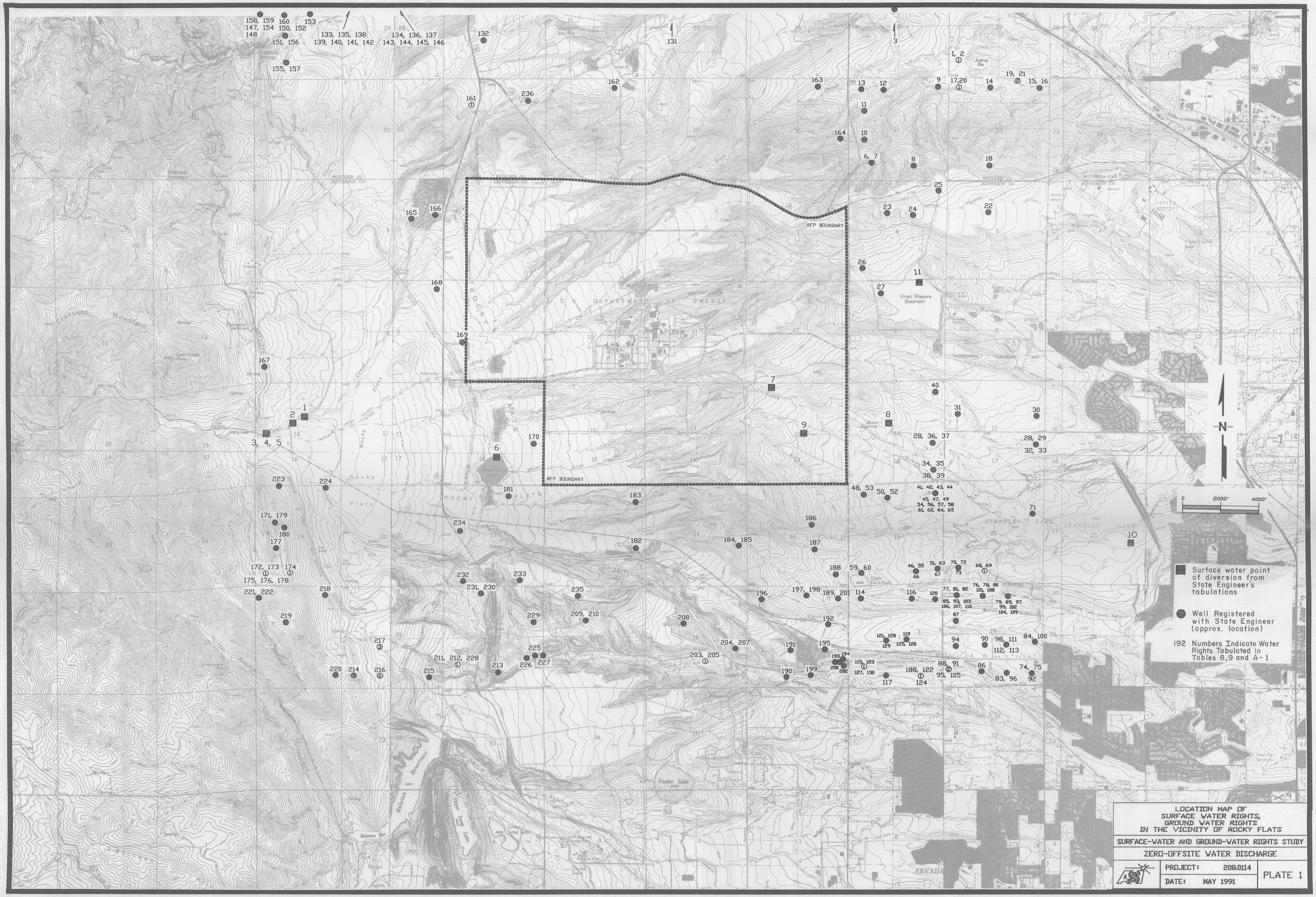
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO-OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: MAY 1991

FIGURE 8



LOCATION MAP OF SURFACE WATER RIGHTS, GROUND WATER RIGHTS IN THE VICINITY OF ROCKY FLATS

SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO-OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: MAY 1991

PLATE 1

APPENDIX A

Ground-Water Rights Data in the Vicinity of Rocky Flats Plant

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
1	6711-F	SW/SW	29	T.1S.	R. 69 W.	6	390	Unk	4526	Hardaway, Robert	6/4/65	Kfh
2	15314	SW/SW	29	T.1S.	R. 69 W.	1	615	150	12	Hardaway, Robert	5/19/63	Kfh
3	8273	SE/NW	30	T.1S.	R. 69 W.	1	185	50	20	Dobbs, Odis	4/4/61	Kl
4	25514	NW/NW	30	T.1S.	R. 69 W.	1	630	275	7	Scriffint, Joe	10/10/65	Kfh
5	48196	NW/SE	30	T.1S.	R. 69 W.	1	610	200	15	Hardaway, Robert	9/10/71	Kfh
6	24243	SW/SW	31	T.1S.	R. 69 W.	1	800	220	25	Hardaway, Robert	7/12/65	Kfh
7	29289	SW/SW	31	T.1S.	R. 69 W.	3	800	215	25	Hardaway, Robert	11/21/66	Kfh
8	34582	SW/SE	31	T.1S.	R. 69 W.	1	333	50	7	Heath, G. D.	4/14/69	Kl
9	44374	NE/NE	31	T.1S.	R. 69 W.	1	80	10	13	Johnson, Robert & June	2/1/71	Ka
10	113864	NW/SW	31	T.1S.	R. 69 W.	0	Unk	Unk	Unk	Waitman, D. B.	4/25/80	--[4]
11	119287	SW/NW	31	T.1S.	R. 69 W.	1	Unk	Unk	Unk	Roberts, B. A.	4/22/81	--
12	105613A	NE/NW	31	T.1S.	R. 69 W.	1	Unk	Unk	Unk	Hart, G. D.	6/22/79	--
13	108871	NW/NW	31	T.1S.	R. 69 W.	1	Unk	Unk	Unk	Smith, M. R.	7/23/79	--
14	96127	NE/NW	32	T.1S.	R. 69 W.	0	Unk	Unk	Unk	Thorngren, D.	1/12/78	--
15	115349	NE/NE	32	T.1S.	R. 69 W.	1	Unk	Unk	Unk	Chmielowiec, S.	7/29/80	--
16	105681	NE/NE	32	T.1S.	R. 69 W.	0	Unk	Unk	Unk	Fuentes, J. J.	4/18/79	--
17	106022A	NW/NW	32	T.1S.	R. 69 W.	1	Unk	Unk	Unk	Kingsbury, D.	5/4/79	--
18	122045	SE/SW	32	T.1S.	R. 69 W.	1	Unk	Unk	Unk	Carmella, K. J.	9/10/81	--
19	126082	NW/NE	32	T.1S.	R. 69 W.	1	Unk	Unk	Unk	Finstad, L.	6/22/82	--

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER (con't.)

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
20	121149	NW/NW	32	T.1S.	R. 69 W.	1	Unk	Unk	Unk	Kois, R. W.	7/28/81	--
21	2600	NW/NE	32	T.1S.	R. 69 W.	1	410	200	10	Int'l Sportsman's Club	5/16/59	Kfh
22	23878F	SE/NW	5	T.2S.	R. 69 W.	4	Unk	Unk	Unk	Jeff Co Airport	10/25/79	--
23	28678F	SE/NW	6	T.2S.	R. 69 W.	8	Unk	Unk	Unk	Carlson, C. F.	6/28/85	--
24	23591F	SW/NE	6	T.2S.	R. 69 W.	8	Unk	Unk	Unk	Jeffco Air Pk.	6/15/79	--
25	23590F	NE/NE	6	T.2S.	R. 69 W.	8	Unk	Unk	Unk	Jeffco Air Pk.	6/15/79	--
26	28779	SW/SW	6	T.2S.	R. 69 W.	1	50	20	1	Blanch, F. J.	9/3/66	Ka
27	9126	NE/NW	7	T.2S.	R. 69 W.	1	50	15	20	McCadden, R. D.	7/8/61	Ka
28	666	NE/SE	17	T.2S.	R. 69 W.	1	95	10	10	Brauch, G.	12/31/57	Ka
29	955	NE/SE	17	T.2S.	R. 69 W.	1	85	8	20	Brauch, E.	1/10/58	Ka
30	13494	SE/NE	17	T.2S.	R. 69 W.	1	142	75	20	Fritzler, G.	11/6/62	Ka
31	15044R	SW/NW	17	T.2S.	R. 69 W.	5	182	90	5	Lyons, M. D.	7/50	Ka
32	30030	NE/SE	17	T.2S.	R. 69 W.	1	182	63	20	Brauch, G.	3/7/67	Ka
33	80021	NE/SE	17	T.2S.	R. 69 W.	1	300	150	15	Smith, R.	8/19/75	Ka
34	132576A	SE/SE	18	T.2S.	R. 69 W.	3	Unk	Unk	Unk	Woodis, B. J.	9/9/83	--
35	103583A	SE/SE	18	T.2S.	R. 69 W.	3	Unk	Unk	Unk	Brauch, K.	12/6/78	--
36	962872	NE/SE	18	T.2S.	R. 69 W.	0	Unk	Unk	Unk	Brauch, T.	1/23/78	--
37	29620	NE/SE	18	T.2S.	R. 69 W.	1	112	29	15	Brauch, D.	1/11/67	Ka
38	52028	SE/SE	18	T.2S.	R. 69 W.	2	122	44	8	Brauch, K.	3/8/72	Ka

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER (con't.)

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
39	132562	SE/SE	18	T.2S.	R. 69 W.	3	10	0	15	Woodis, B. J.	1922	Qa
40	132563	NE/NE	18	T.2S.	R. 69 W.	1	10	0	5	Woodis, B. J.	6/48	Qa
41	138834	NE/NE	19	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Wacker, B.H.	3/13/85	--
42	26A	NE/NE	19	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Ladwig, A. E.	6/27/57	--
43	104756	NE/NE	19	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Welt, D. L.	3/1/79	--
44	89558	NE/NE	19	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Ladwig, W. E.	4/13/77	--
45	131220	NE/NE	19	T.2S.	R. 69 W.	0	Unk	Unk	Unk	Wertz, R. H.	7/7/81	--
46	65747A	SW/SE	19	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Bartlett, R. S.	3/7/83	--
47	122624	NE/NE	19	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Wertz, R. H.	10/13/81	--
48	26730F	NW/NW	19	T.2S.	R. 69 W.	6	Unk	Unk	Unk	Cook, M. E.	8/5/83	--
49	104756	NE/NE	19	T.2S.	R. 69 W.	0	Unk	Unk	Unk	Welt, D. L.	4/8/81	--
50	26942F	NE/NW	19	T.2S.	R. 69 W.	8	Unk	Unk	Unk	Cook, M. E.	11/8/84	--
51	139972	SE/SE	19	T.2S.	R. 69 W.	3	Unk	Unk	Unk	Coleman, J. R.	6/17/85	--
52	131841	NE/NW	19	T.2S.	R. 69 W.	6	Unk	Unk	Unk	Cook, M.E.	8/2/83	--
53	26937F	NW/NW	19	T.2S.	R. 69 W.	8	Unk	Unk	Unk	Cook, M.E.	11/3/84	--
54	26	NE/NE	19	T.2S.	R. 69 W.	1	66	27	15	Ladwig, A. E.	6/27/57	Ka
55	223	SW/SE	19	T.2S.	R. 69 W.	1	110	10	6	Schofield, James & Betty	8/28/57	Ka
56	1246	NE/NE	19	T.2S.	R. 69 W.	1	67	6	15	Church, M. F.	5/29/58	Ka
57	8117	NE/NE	19	T.2S.	R. 69 W.	1	70	22	22	Peterson, N. L.	3/30/61	Ka
58	14820	NE/NE	19	T.2S.	R. 69 W.	1	70	12	8	Welt, D.	4/23/63	Ka

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER (con't.)

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
59	15251	SW/SW	19	T.2S.	R. 69 W.	1	86	20	20	Bray, M. V.	5/15/63	Ka
60	15252	SW/SW	19	T.2S.	R. 69 W.	1	86	20	20	Bray, M. V.	5/12/63	Ka
61	18383	NE/NE	19	T.2S.	R. 69 W.	1	75	30	12	Peterson, N. L.	9/21/63	Ka
62	19069	NE/NE	19	T.2S.	R. 69 W.	1	100	16	6	Welt, D.	3/26/64	Ka
63	32467	SE/SE	19	T.2S.	R. 69 W.	1	115	35	8	Coleman, J. R.	11/7/67	Ka
64	32849	NE/NE	19	T.2S.	R. 69 W.	1	80	15	14	Peterson, N. L.	1/11/68	Ka
65	45855	NE/NE	19	T.2S.	R. 69 W.	1	110	15	15	Chisolm, B. D.	5/20/71	Ka
66	65747	SW/SE	19	T.2S.	R. 69 W.	3	120	45	15	Coleman, J. R.	11/9/72	Ka
67	87059	SE/SE	19	T.2S.	R. 69 W.	1	140	30	5	Coleman, J. R.	8/10/78	Ka
68	129919	SE/SW	20	T.2S.	R. 69 W.	0	Unk	Unk	Unk	Robbins, J. R.	11/4/84	--
69	98697	SE/SW	20	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Robbins, J. R.	5/16/78	--
70	556	SW/SW	20	T.2S.	R. 69 W.	1	185	35	20	Paiz, Vincent & Rafeleta	11/20/58	Ka
71	25429	SE/NE	20	T.2S.	R. 69 W.	1	40	4	4	Stein, C.	10/20/65	Ka
72	29754	SW/SW	20	T.2S.	R. 69 W.	1	240	45	20	Abbott, R. M.	2/10/67	Ka
73	39001	SW/SW	20	T.2S.	R. 69 W.	1	170	41	15	Hurd, H.	8/14/69	Ka
74	137604	SE/SE	29	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Taylor, A.	10/22/84	--
75	139694	SE/SE	29	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Bellante, L. B.	5/28/85	--
76	89110	NE/NW	29	T.2S.	R. 69 W.	Unk	Unk	Unk	Unk	Vendegna, E. M.	3/30/77	--
77	133829	NW/NW	29	T.2S.	R. 69 W.	0	Unk	Unk	Unk	Gantenbein, K.	12/7/83	--
78	114256	NE/NW	29	T.2S.	R. 69 W.	0	Unk	Unk	Unk	Chavez, N. R.	5/22/80	--

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER (con't.)

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
79	82809A	NW/NE	29	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Krantz, D. E.	10/3/83	--
80	61192A	NE/NW	29	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Eckert, R. L.	10/17/84	--
81	129190	NW/NW	29	T.2S.	R. 69 W.	0	Unk	Unk	Unk	Kinnie, L.	2/24/83	--
82	128355	NW/NW	29	T.2S.	R. 69 W.	0	Unk	Unk	Unk	Eberstadt/Wise	11/30/82	--
83	138949	SW/SE	29	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Robinson, G. E.	3/9/85	--
84	2049	NE/SE	29	T.2S.	R. 69 W.	1	72	14	6	Kratochvil, C.	11/3/58	Qa
85	11621	NW/NW	29	T.2S.	R. 69 W.	1	165	75	2	Martinez, J.	5/21/62	Ka
86	13803	SE/SW	29	T.2S.	R. 69 W.	1	80	25	2	Pusok, John & Judy	12/10/62	Qa
87	14099	SW/NW	29	T.2S.	R. 69 W.	1	265	140	7	George, D. K.	2/10/63	Ka
88	23528	SW/SW	29	T.2S.	R. 69 W.	1	100	15	3	Mounts, L.	4/27/65	Qa
89	25218	NW/NE	29	T.2S.	R. 69 W.	1	305	125	12	Taylor, A.W.	9/4/65	Ka
90	31590	NE/SW	29	T.2S.	R. 69 W.	1	290	183	7	Harper, D. C.	7/21/67	Ka
91	33005	SW/SW	29	T.2S.	R. 69 W.	1	255	157	8	Brewer, A. W.	3/4/68	Ka
92	37262	SE/SE	29	T.2S.	R. 69 W.	1	427	245	15	Robinson, F.	4/7/69	Ka
93	37296	NW/NW	29	T.2S.	R. 69 W.	1	207	40	15	Coleman, J.	4/3/69	Ka
94	38217	NW/SW	29	T.2S.	R. 69 W.	1	315	150	25	Bloom, L. D.	6/24/69	Ka
95	40814	SW/SW	29	T.2S.	R. 69 W.	1	317	175	20	Wiser, G. R.	4/15/70	Ka
96	45728	SW/SE	29	T.2S.	R. 69 W.	1	290	80	15	Horst, P. A.	6/30/71	Ka
97	52877	NW/NE	29	T.2S.	R. 69 W.	1	300	45	15	Mace, D. M.	3/16/72	Ka
98	52998	NW/SE	29	T.2S.	R. 69 W.	1	300	Unk	15	Deubel, W. B.	9/1/74	Ka

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER (con't.)

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
99	54046	NW/NE	29	T.2S.	R. 69 W.	1	270	112	15	Macrind, G.	9/1/74	Ka
100	55735	NE/SE	29	T.2S.	R. 69 W.	1	365	0	7	Hake, L. H.	5/17/54	Ka
101	61192	NE/NW	29	T.2S.	R. 69 W.	1	300	100	14	Eckert, R. L.	9/7/73	Ka
102	63995	NW/NE	29	T.2S.	R. 69 W.	1	330	140	15	Harris, L. W.	7/25/75	Ka
103	66103	NW/NW	29	T.2S.	R. 69 W.	1	320	150	1	Edgett, J.	3/13/74	Ka
104	66359	NW/NE	29	T.2S.	R. 69 W.	0	320	160	10	Hersch, R. B.	1/29/74	Ka
105	70316	SW/SW	29	T.2S.	R. 69 W.	3	345	155	10	Haynes, D.	2/2/76	Ka
106	70958	NW/NW	29	T.2S.	R. 69 W.	1	340	140	12	Deselms, G. R.	8/23/74	Ka
107	73291	NW/NW	29	T.2S.	R. 69 W.	0	300	90	12	Tilton, D. R.	9/16/74	Ka
108	73870	NE/NW	29	T.2S.	R. 69 W.	0	300	100	10	Skaggs, J.	10/10/74	Ka
109	75034	NW/NE	29	T.2S.	R. 69 W.	0	300	150	10	Doehling, C. F.	4/3/75	Ka
110	76567	NW/NW	29	T.2S.	R. 69 W.	0	300	70	10	Schreiner, D.	12/20/74	Ka
111	89233	NW/SE	29	T.2S.	R. 69 W.	1	175	Unk	7	Badey, J. K.	1950	Ka-Qa
112	89234	NW/SE	29	T.2S.	R. 69 W.	1	110	0	12	Badey, J. K.	1950	Qa
113	93711	NW/SE	29	T.2S.	R. 69 W.	1	100	50	15	G & B Truck Leasing	1/53	Qa
114	126136A	NW/NW	30	T.2S.	R. 69 W.	1	Unk	Unk	5	Bulinski, E.	11/16/77	--
115	95039	SW/SW	30	T.2S.	R. 69 W.	1	Unk	Unk	3	John, L.	12/2/79	--
116	104321	NW/NE	30	T.2S.	R. 69 W.	0	Unk	Unk	Unk	Downey, T.	12/10/84	--
117	138155	SW/SE	30	T.2S.	R. 69 W.	1	Unk	Unk	Unk	Karst, D. A.	3/16/83	--
118	129408	SE/SW	30	T.2S.	R. 69 W.	0	Unk	Unk	Unk	Dutton, L.	3/16/83	--

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER (con't.)

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
119	1432	NW/SE	30	T.2S.	R. 69 W.	1	146	50	5	Pearce, J. C.	6/29/58	Qa
120	2588	NE/NE	30	T.2S.	R. 69 W.	2	52	22	3	Rodgers, F. A.	12/13/58	Qa
121	3798	NE/SW	30	T.2S.	R. 69 W.	1	165	80	12	Davis, L.	7/17/59	Ka
122	5357	SE/SW	30	T.2S.	R. 69 W.	1	180	90	10	Campbell, C.	3/30/60	Ka
123	10670	SW/SW	30	T.2S.	R. 69 W.	1	121	28	20	Pearce, E.	2/11/62	Ka
124	12379	SE/SW	30	T.2S.	R. 69 W.	1	190	70	12	Session, B.	7/25/62	Ka
125	16523	NW/SE	30	T.2S.	R. 69 W.	1	270	110	5	Northwest Bible Church	6/22/63	Ka
126	36576	NW/SE	30	T.2S.	R. 69 W.	1	310	188	15	Tolowitzki, A.	2/3/67	Ka
127	39352	SW/SW	30	T.2S.	R. 69 W.	2	195	103	15	Cozza, L. A.	9/17/69	Ka
128	50074	NE/SW	30	T.2S.	R. 69 W.	1	200	82	15	Reigel, D. H.	12/13/71	Ka
129	81301	NE/SW	30	T.2S.	R. 69 W.	1	331	110	4	Newell, J.	8/15/76	Ka
130	95039	SW/SW	30	T.2S.	R. 69 W.	1	1060	190	15	John, L.	1/28/78	Kl
131	12307	NE/NE	26	T.1S.	R. 70 W.	1	125	45	2	Wilson, T. L.	7/14/62	Upgradient
132	16207F	NW/SE	28	T.1S.	R. 70 W.	4	650	23	30	Cinaquanta, F.	4/20/73	Upgradient
133	994	NW/NW	29	T.1S.	R. 70 W.	1	25	8	14	Wilson, H.	3/20/58	Upgradient
134	1531	NE/NW	29	T.1S.	R. 70 W.	1	28	3	30	Pearson, W. W.	7/1/58	Upgradient
135	11216	NW/NW	29	T.1S.	R. 70 W.	1	12	2	5	Shew, J. E.	3/8/62	Upgradient
136	14644	NE/NW	29	T.1S.	R. 70 W.	1	35	10	0	Greer, D.	4/19/63	Upgradient
137	14839	NE/NW	29	T.1S.	R. 70 W.	1	36	10	10	Greer, D.	4/19/63	Upgradient
138	40816	NW/NW	29	T.1S.	R. 70 W.	1	25	15	15	VanDonkelaar, W.	5/3/70	Upgradient

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER (con't.)

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
139	43693	NW/NW	29	T.1S.	R. 70 W.	1	19	6	15	VanDonkelaar, W.	11/17/70	Upgradient
140	50815	NW/NW	29	T.1S.	R. 70 W.	1	25	3	15	Volz, B.	1/26/72	Upgradient
141	61766	NW/WN	29	T.1S.	R. 70 W.	1	35	8	25	Corning, D.	8/12/72	Upgradient
142	62213	NW/NW	29	T.1S.	R. 70 W.	1	120	10	5	Helart, H.	4/1/15	Upgradient
143	64128	NE/NW	29	T.1S.	R. 70 W.	0	40	6	7	Wallace, B. O.	5/21/73	Upgradient
144	68407	NE/NW	29	T.1S.	R. 70 W.	0	55	10	12	South, S.	8/74	Upgradient
145	101711A	NE/NW	29	T.1S.	R. 70 W.	1	Unk	Unk	Unk	Taylor, W. R.	9/8/78	Upgradient
146	88897	NE/NW	29	T.1S.	R. 70 W.	0	Unk	Unk	Unk	O'Neill, M.	3/18/77	Upgradient
147	3714	NW/SW	30	T.1S.	R. 70 W.	1	23	6	10	Taylor, I. B.	6/16/59	Upgradient
148	9418	SW/NW	30	T.1S.	R. 70 W.	1	52	20	4	Bell, J.	5/2/61	Upgradient
149	13248R	SW/NE	30	T.1S.	R. 70 W.	7	10	1	890	Bell, J. N.	1888	Upgradient
150	13249R	SW/NE	30	T.1S.	R. 70 W.	7	30	5	225	Bell, J. N.	1905	Upgradient
151	17834	NE/SW	30	T.1S.	R. 70 W.	1	215	95	3	VanDonkelaar, B.	9/27/63	Upgradient
152	18154	SW/NE	30	T.1S.	R. 70 W.	1	70	30	2	Reynolds, H.	10/4/63	Upgradient
153	35435	SW/NE	30	T.1S.	R. 70 W.	1	35	Unk	4526	Reynolds, A.	10/1/68	Upgradient
154	36497	NW/SW	30	T.1S.	R. 70 W.	1	22	12	40	Denver Water Comm.	7/38	Upgradient
155	40979	SW/SE	30	T.1S.	R. 70 W.	1	98	6	12	Cooper, J. W.	4/23/70	Upgradient
156	41320	NE/SW	30	T.1S.	R. 70 W.	1	700	100	1.5	VanDonkelaar, W.	4/3/79	Upgradient
157	41712	SW/SE	30	T.1S.	R. 70 W.	1	100	8	3	Reynolds, E.	6/22/70	Upgradient
158	128433	NW/SW	30	T.1S.	R. 70 W.	1	12	0	5	Levin, E. D.	4/1/26	Upgradient

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER (con't.)

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
159	120733A	NW/SW	30	T.1S.	R. 70 W.	1	Unk	Unk	Unk	Bailey, C. D.	7/6/81	--
160	112722A	NW/SE	30	T.1S.	R. 70 W.	1	Unk	Unk	Unk	Robinson, K. M.	2/4/80	--
161	2862	SW/NW	33	T.1S.	R. 70 W.	1	74	17	1	Weaver, J. E.	2/26/59	Upgradient
162	88218	NW/NE	34	T.1S.	R. 70 W.	0	Unk	Unk	Unk	Hill, T. C.	1/31/77	--
163	15060	NW/NE	36	T.1S.	R. 70 W.	1	100	40	1	Swanson, H. L.	4/12/63	Kl
164	130482	NE/SE	36	T.1S.	R. 70 W.	1	Unk	Unk	Unk	Verhey, R. J.	5/23/83	--
165	2651F	SW/NE	5	T.2S.	R. 70 W.	5	18	5	100	Idealite Company	3/1/61	Upgradient
166	3338	SE/NE	5	T.2S.	R. 70 W.	1	50	0	10	Hogan, E. J.	10/59	Upgradient
167	91184	SW/SW	7	T.2S.	R. 70 W.	1	Unk	Unk	Unk	Ranson, A. L.	6/24/78	--
168	42120	NE/NE	8	T.2S.	R. 70 W.	1	200	5	20	Daniels, W. J.	8/29/70	Upgradient
169	28915	NW/SW	9	T.2S.	R. 70 W.	2	18	8	2	Church, M. F.	10/65	Upgradient
170	17190F	NE/SE	16	T.2S.	R. 70 W.	4	604	6	150	Colo. Board Land Comm.	12/27/74	Kl
171	11877	SW/NW	19	T.2S.	R. 70 W.	1	325	45	6	Hollinger, D. A.	5/7/62	Upgradient
172	13018	SW/SW	19	T.2S.	R. 70 W.	1	110	20	1	Kellogg, C. R.	9/7/62	Upgradient
173	13439F	SW/SW	19	T.2S.	R. 70 W.	8	465	105	17	Blue Mountain Corp.	1/21/69	Upgradient
174	28408	SE/SW	19	T.2S.	R. 70 W.	1	308	139	1	Lord, R. E.	8/9/66	Upgradient
175	33695	SW/SW	19	T.2S.	R. 70 W.	1	80	80	5	Tschiffely, F. A.	7/20/68	Upgradient
176	35711	SW/SW	19	T.2S.	R. 70 W.	1	410	Unk	4526	Hepp, B. C.	10/30/68	Upgradient
177	45022	NW/SW	19	T.2S.	R. 70 W.	1	230	30	9	Martens, W.	4/1/71	Upgradient

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER (con't.)

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
178	53597	SW/SW	19	T.2S.	R. 70 W.	1	200	43	Unk	Smith, W. C.	Unk	Upgradient
179	67546	SW/NW	19	T.2S.	R. 70 W.	1	253	50	7	Rouse, G. E.	3/9/73	Upgradient
180	72601	SE/NW	19	T.2S.	R. 70 W.	0	260	0	0	Snow, R. A.	12/18/73	Upgradient
181	3257	NW/NE	21	T.2S.	R. 70 W.	1	430	90	15	Church, M. F.	4/22/59	Upgradient
182	10003F	NE/SE	22	T.2S.	R. 70 W.	5	1090	Unk	30	Oil Shale Corp.		Kl
183	23787F	NE/NE	22	T.2S.	R. 70 W.	4	Unk	Unk	Unk	Cillessen, A. M.	4/26/78	--
184	131860	NE/SE	23	T.2S.	R. 70 W.	4	Unk	Unk	Unk	Storm, B. P.	1/12/81	--
185	131861	NE/SE	23	T.2S.	R. 70 W.	4	Unk	Unk	Unk	Bartel, L. G.	1/12/81	--
186	2679F	SW/NE	24	T.2S.	R. 70 W.	5	500	281	50	Boise Cascade Corp.	8/18/60	Kl
187	20196	NW/SE	24	T.2S.	R. 70 W.	3	101	70	16	City of Westminster	5/27/64	Ka
188	34955	SE/SE	24	T.2S.	R. 70 W.	1	405	135	15	Stevens, D. N.	8/14/68	Kl
189	97839A	NE/NE	25	T.2S.	R. 70 W.	1	Unk	Unk	Unk	Taylor, L. O.	2/21/78	--
190	2925F	SE/SW	25	T.2S.	R. 70 W.	4	812	230	20	Public Service Company	3/21/61	Kl
191	4746	NE/SW	25	T.2S.	R. 70 W.	1	200	0	4526	Welke, M. W.	10/27/59	Ka
192	7848	SE/NE	25	T.2S.	R. 70 W.	1	1220	365	30	Oriental Refining	4/19/61	Kfh
193	17337	SE/SE	25	T.2S.	R. 70 W.	1	170	50	20	Remington, W.	9/10/63	Ka
194	18722	SE/SE	25	T.2S.	R. 70 W.	1	1050	180	22	Remington, W.	12/18/63	Kfh
195	25117	NE/SE	25	T.2S.	R. 70 W.	1	190	95	20	Neuber, C.	8/24/65	Ka
196	34149	NW/NW	25	T.2S.	R. 70 W.	1	80	Unk	4526	Mentgen, G.	6/10/68	Ka

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER (con't.)

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
197	34541	NW/NE	25	T.2S.	R. 70 W.	1	115	40	0	Collicott, D. W.	7/11/68	Ka
198	35405	NW/NE	25	T.2S.	R. 70 W.	1	100	60	4526	Collicott, D. W.	9/20/68	Ka
199	37604	SW/SE	25	T.2S.	R. 70 W.	1	70	10	6	Cheatham, S.	4/28/69	Ka
200	41313	SE/SE	25	T.2S.	R. 70 W.	1	1060	362	25	Remington, W.	5/22/70	Kfh
201	61190	NE/NE	25	T.2S.	R. 70 W.	1	320	100	2	Animal Relief Foundation	5/4/72	Kl
202	82199	SE/SE	25	T.2S.	R. 70 W.	1	28	Unk	8	Branc, K. A.	1890	Qa
203	2867F	SE/SW	26	T.2S.	R. 70 W.	4	715	260	550	Public Service	1/10/61	Kl
204	7619F	SE/SE	26	T.2S.	R. 70 W.	8	16	100	30	Leyden Water Dist.	6/20/57	Qa
205	13663F	SE/SW	26	T.2S.	R. 70 W.	4	862	Unk	160	Public Service Company	4/19/62	Kl
206	34970	NE/SE	26	T.2S.	R. 70 W.	1	50	18	5	Salas, B.	8/14/68	Qa
207	39737	SE/SE	26	T.2S.	R. 70 W.	1	30	17	20	Davis, P.	11/7/69	Qa
208	78493	SE/NW	26	T.2S.	R. 70 W.	2	Unk	Unk	15	Harkness, W. W.	4/15/50	--
209	24583F	SE/NW	27	T.2S.	R. 70 W.	5	Unk	Unk	Unk	Public Service Company	11/29/79	--
210	2868F	NW/SE	27	T.2S.	R. 70 W.	4	784	300	600	Public Service Company	1/31/61	Kl
211	139260	SW/SW	28	T.2S.	R. 70 W.	1	Unk	Unk	Unk	Lewis, S. C.	6/21/84	--
212	139259	SW/SW	28	T.2S.	R. 70 W.	1	Unk	Unk	Unk	Lewis, S. C.	6/21/84	--
213	21762	SW/SE	28	T.2S.	R. 70 W.	1	50	4	20	Lindsay, G.	1900	Upgradient
214	139556	SW/SW	29	2S	70W	1	Unk	Unk	Unk	Steinhoff, S.	3/20/85	--
215	90532	SE/SE	29	2S	70W	0	Unk	Unk	Unk	McElhinney	4/29/77	--

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER (con't.)

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
216	139064	SE/SW	29	2S	70W	1	Unk	Unk	Unk	Spano, P. J.	3/6/85	--
217	139065	NE/SW	29	2S	70W	1	Unk	Unk	Unk	Spano, P. J.	3/6/85	--
218	115658	NE/NE	30	2S	70W	1	Unk	Unk	Unk	Walter, R. M.	7/9/80	--
219	116029	SE/NW	30	2S	70W	1	Unk	Unk	Unk	Lacy, H.	8/8/80	--
220	107310	SE/SE	30	2S	70W	1	Unk	Unk	Unk	Scherer, C. T.	4/9/79	--
221	31673	NW/NW	30	2S	70W	1	500	300	15	Kilgore, J. P.	8/17/67	Upgradient
222	38979	NW/NW	30	2S	70W	1	230	146	10	Papke, G. R.	8/25/69	Upgradient
223		NW/NE/NW	19	2S	70W							Upgradient
224		NW/NE/NE	19	2S	70W							Upgradient
225		SE/NE/SE	28	2S	70W							Upgradient
226		SE/NE/SE	28	2S	70W							Upgradient
227		SE/NE/SE	28	2S	70W							Upgradient
228		NE/SW/SW	28	2S	70W							Upgradient
229		NE/SE/NE	28	2S	70W							Upgradient
230		NE/NW/NW	28	2S	70W							Upgradient
231		NE/NW/NW	28	2S	70W							Upgradient
232		SW/SE/SE	21	2S	70W							Upgradient
233		SE/SW/SW	21	2S	70W							Upgradient
234		SE/SW/NW	21	2S	70W							Upgradient
235		SW/NE/NW	27	2S	70W							Upgradient

TABLE A-1. WELLS REGISTERED WITH THE COLORADO STATE ENGINEER (con't.)

Reference Number[1]	Permit Number	Location				Use[2]	Well Depth (feet)	Water Level (feet)	Yield (gpm)	Owner	Construction Date	Estimated Formation of Completion[3]
		Quarter	Sec.	Tsp.	Range							
236		NW/SE/NE	33	1S	70W							Upgradient

NOTES: 1) Shown on Plate 1

2) Uses:

0 Household Use Only	3 Domestic & Stock	5 Industrial
1 Domestic - Household & Lawn	4 Commercial	6 Irrigation
2 Stock	7 Domestic & Irrigation	8 Municipal

Source: Modified from Colorado State Engineer Tabulations based upon Aerial Photographs and Field Reconnaissance.

3) For Cogradient and Downgradient well only
Qa - Alluvial Valley Fill
Ka - Cretaceous Araphoe Formation
Kl - Cretaceous Laramie Formation
Kfh - Cretaceous Fox Hills Formation

4) -- Unable to determine

TABLE A-2. FIELD CHECK OF WELL LOCATIONS

BEGIN EAST ON LEYDEN ROAD FROM STATE HIGHWAY 93

Well #[1)]	LOCATION	DESCRIPTION
213	1 well	Wood shack on brick foundation, power line and meter leading in
225 226 227	3 wells; Cannot Different- tiate	3 C.I. well casings, no appurtenances 3 or 4 stakes surrounding each Each casing approximately 3' above ground; estimated 100 yards apart, parallel to stream
209 210	Not Identified	A residence north of road, several structures to south Several pumps and tanks in/on ground; wells could be associated with residences and not apparent
203 205	1 well	Leyden storage field fenced areas with cisterns "Shaft #2", "Shaft #1", "Well #20" Other fenced areas without signs; signs I.D.: Public Service/Leyden Sto. Field/Jeffco 303-571-7811, emergency number
204 207	Not Identified	No wells identified; many residences Wells may be in buildings or otherwise not apparent
190	Not Identified	No well identified; residence in immediate area
199	Not Identified	No well identified; residence in immediate area; residence with small cistern in yard
193 194 200 202	4 wells	Two C.I. well casings (approx. 6" dia., 1' to 2' above ground), no markings; padlocked--one piezometer, PVC, 1" dia. clustered near road on north side; one C.I. well casing on south side of road approximately 80' SW of others; no appurtenances on any; one C.I. well casing west 200 yards; several piezometers Vicious guard dogs

TABLE 1-2. FIELD CHECK OF WELL LOCATIONS (Continued)

Well #[1)]	LOCATION	DESCRIPTION
115 123 127 130	1 Well Identified	One C.I. well casing, on ranch with residence north side of road near Indiana One PVC 4" dia. in front yard of residence on north side of road - may be septic vault
118 122 124 117	1 Well ?	Septic truck seen; residences with fields line the road north and south; large field with 4 stakes, no wells seen with stakes, but grass high; NW/NW may relate to 117; one stake had well casing-like structure next to it.
88 91 95 105	2 Wells ?	Open ranch area, animal grazing One pump/cistern--hand pump out of ground well? One steel well casing "C&B" stamped on size 12" above ground: 8" dia., unsure of others residences
86	No ID	Residences with small ranches; no specific wells seen
83 96	No ID	May be disguised
74 75 92	No ID	Vacant area except for two buildings Grace Evangelical Church and some type of warehouse; looks in part to be an abandoned construction effort; sign indicating church and gym for sale (Telephone: 988-8288)
84 100	No ID	Residences, junk yard Somewhat open
98 111 112 113	No ID	Residences; some ranches and horses
90	No ID	Residences, ranches w/horses

TABLE 1-2. FIELD CHECK OF WELL LOCATIONS (Continued)

Well #[1)]	LOCATION	DESCRIPTION
94	No ID	Residences, ranches w/horses
79 89 97 99 102 104 109	No ID	Residential
76 78 80 101 108	No ID	Residential
77 81 82 85 93 103 106 107 110	No ID	Residential
68 69	1 Well	One C.I. well in "Open Space"; welded closed; residence nearby
70 72 73	No ID	Residences--some with ranches, boat storage
51 63 67	No ID	Ranches, large horse farm Cisterns seen but no pumps

TABLE 1-2. FIELD CHECK OF WELL LOCATIONS (Continued)

Well #[1)]	LOCATION	DESCRIPTION
71	No ID	Location appears to be within Standley Lake
120 116	No access	
46 55 66	No Access	
41 42 43 44 45 47 49 54 56 57 58 61 62 64 65		Large ranches and residences; no observed wells Could be approx. 1 well per residence One Residence: Bill and Donna Amen - 467-0031 Amen Acres
34 35 38 39	No ID	2 residences, horse ranches
30		Fallow field; "Westminster Open Space"; no well; it should be obvious
28 29 32 33	No wells identified	Residence, not ranches 1 horse area, then "Open Space"

TABLE 1-2. FIELD CHECK OF WELL LOCATIONS (Continued)

Well #[1)]	LOCATION	DESCRIPTION
31	No ID	Residence/ranch
40		No way of telling; on farmland
BEGIN AT JUNCTION OF LEYDEN AND INDIANA		
195		No well identified; Residence in immediate area, No one was home, property fenced off.
192		Same as #195
191		Same as # 195 However, did not try to make contact.
119 125 126 121 128 129	Not Identified	Large open field, fenced in with cattle and horses. However, no wells seen. Some post standing alone in the middle of the field with no obvious sign of a well.
WEST OF STATE HIGHWAY 93		
228 211 212	1 Well	CI in cow pasture, surrounded by chickenwire, 2' above ground - No appurtenances Large ranch with several homes
215	No ID	Several ranch residences; One cistern seen with no well or pump
216 214?	6 Wells 1 Pump	"Fire Cistern" 6 - 4" diameter PVC wells capped Covered and locked cistern, dipstick No appurtenances to wells, but in area other piping, etc. 1 hand pump over concrete vault (4' x 6') Pump on 1-1/2 diameter SS pipe out of ground.

TABLE 1-2. FIELD CHECK OF WELL LOCATIONS (Continued)

Well #[1)]	LOCATION	DESCRIPTION
217	1 Well	4" diameter PVC with cap, no appurtenances, 100 feet from residence - septic?
	1 Well	4" diameter PVC with cap, no appurtenances, 100 feet from another residence - both residences are about 1 year old - septic?
	1 Well	With hand pump adjacent - Next to residence Well 4" diameter PVC, hand pump 1" diameter ss llamas in field-Another hand pump next to llama barn
230 231	No ID	Open fields - cows grazing No wells seen - One residence - south of area
233	No ID	Open fields - cows grazing; no wells seen - no residences
232	No ID	BFI Landfill Area - Buildings may have well
218	No ID	Open fields, no obvious well, no residences
224	No ID	Residence in area
223	No ID	Residence in area
177 179	No ID	Residences in area
171	No ID	Residences
180	No ID	Residences
172 173 175 176 178	1 Well	Residences 1 C.I. well welded closed next to sewer access and fire hydrant Fire hydrant around - municipal water
221 222	No ID	Residences
174	1 Well	Hand pump by cistern in horse field

TABLE 1-2. FIELD CHECK OF WELL LOCATIONS (Continued)

Well #[1)]	LOCATION	DESCRIPTION
219	No ID	Residences
220	No Access	
180	No ID	Residences
167	No Access	Open Field - but hilly - obstructed view
169	No ID	Open Field
168	No ID	Saw Mill in area - probably has well, several buildings
165	No ID	Quarry and two ranches
166		No well visible
161		Concrete cistern with lid 3' diameter 3' high No appurtenances - in Boulder Open Space - actually in SE/NW not SW/NW
236	No ID	"Open Space" No well seen, no structures
132	No ID	Ruins of building, smaller buildings 2 CI 12" diameter pipes from concrete pad - rusted open No appurtenances
134	No ID	Abundant residences, many with horses.
136		Several cisterns in pastures - none with hand pumps
137		A few hand pumps seen - but near houses.
143		Obvious sprinkler systems near big houses.
144		
145		
146		
133	No ID	As above
135		
138		
139		
140		
141		
142		

TABLE 1-2. FIELD CHECK OF WELL LOCATIONS (Continued)

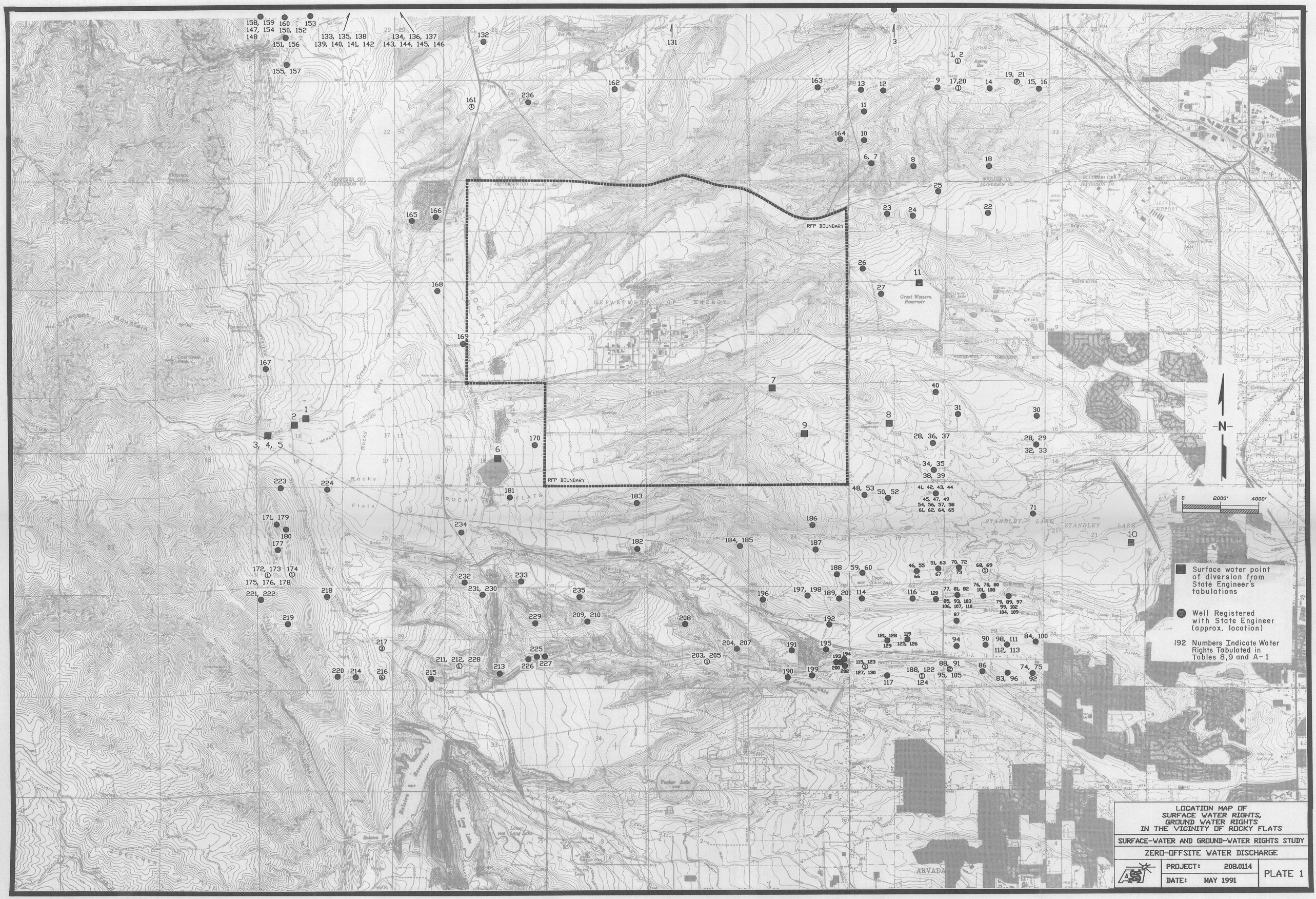
Well #[1)]	LOCATION	DESCRIPTION
151 156	No ID	Residences - many quite old
160	No ID	As above
153	No ID	As above
148	No ID	Residences - many very old
158 159 147 154	No ID	As above
149 150 152	No ID	As above
155 157	No ID	Residences - at least 2; Yoga Institute with horses
BEGIN AT STATE HIGHWAY 93 AND LEYDEN		
229	No ID (No access)	All off road land fenced in with "No Trespassing" signs. All access roads locked.
235		Same as above
208		Same as above
206	No ID	Commercial buildings, warehouse in area

TABLE 1-2. FIELD CHECK OF WELL LOCATIONS (Continued)

Well #[1)]	LOCATION	DESCRIPTION
197 198	No ID	Open land with cattle and access roads, also fences with "No Trespassing" signs. No wells seen. House with garage and country market store - buildings all deserted and for sale. Also an industrial complex to the west.
196	No ID	Right off Hwy. 72, on north side is a large water tank and a small building. The building has an electrical line leading in with a meter. Otherwise, open fields with no wells seen.
184 185	No ID	Rolling hills, open space with no access and no wells sighted.
182	No ID	No wells seen in the open spaces. However in the industrial business area another water tank approximately 30' high and 30' in diameter with a small building that has power lines leading in and 5" faucets on the outside. Fire hydrants in area.
189 201	No ID	Residences, cattle, horses, and all fenced off. No signs of well.
114	No ID	Same as above
188	No ID	Same as above
187	No ID	Same as above
186	No ID	Same as above
59 60	No ID	Same as above
48 53	No ID	Same as above
50	No ID	Same as above

TABLE 1-2. FIELD CHECK OF WELL LOCATIONS (Continued)

Well #[1)]	LOCATION	DESCRIPTION
52		
36 37	No ID	Same as above
26	No ID	Open fields with cattle and horses present. No wells sighted.
27	No ID	Open fields with cattle and horses present. No wells sighted.
23 24 25 22	No ID	Open fields with cattle and horses present. No wells sighted.
8	No ID	Open land along with very steep and hilly terrain.
18	No ID	Open land along with very steep and hilly terrain.
6 7	1 Well	In front of commercial buildings. A 1" pipe with a hand pump on it. 3' high. 3 residences in area with restricted access. No sightings of other well. Open rolling, hilly topography.
10	No ID	Residence in vicinity; cattle and horses, fenced in.
164	No ID	Residence in vicinity; cattle and horses, fenced in.
11 13 163	No ID	Residence in vicinity; cattle and horses, fenced in.
12	No ID	Open fields, fenced in cattle and horses present. House in vicinity.



LOCATION MAP OF
SURFACE WATER RIGHTS,
GROUND WATER RIGHTS
IN THE VICINITY OF ROCKY FLATS

SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO-OFFSITE WATER DISCHARGE

PROJECT: 208.0114

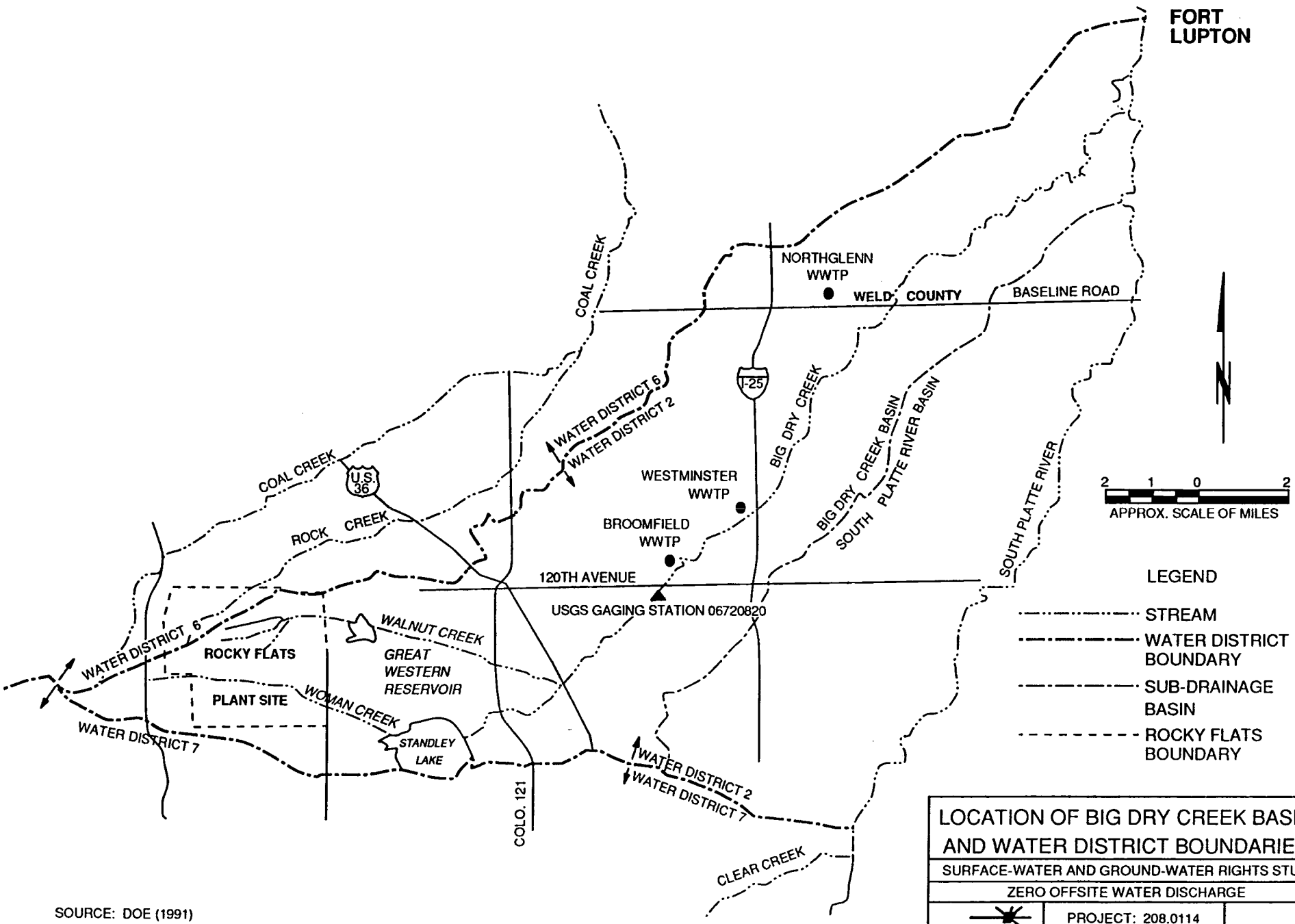
DATE: MAY 1991

PLATE 1

TABLE 1-2. FIELD CHECK OF WELL LOCATIONS (Continued)

Well #[1)]	LOCATION	DESCRIPTION
9	No ID	Open fields, fenced in cattle and horses present. House in vicinity.
1	1 Well	In front of a house, next to a circular metal plate on the ground, is a hand pump on top of a 3' high, 1" pipe hose attached.
2	No ID	House with cattle and horses fenced in.
17 20	1 Well?	In the house's side yard is a pipe extension 20 approximately 1' out of the ground. 6" diameter with a 1" PVC pipe coming out next to it. Both capped with a single cap. Nothing else seen.
19 21	2 Wells?	Two houses side by side. One has a bathtub about 40 yards in front of house with a hose piled next to it. The other has a small fenced in area on its side about 50 yards away from the house was two large metal basins (approximately 100 gal & 50 gal)
14	No ID	Fenced in single residence. No sign of well.
15 16	No ID	Fenced in single residence. No sign of well.

1) As shown in Table A-1 and Plate I.



SOURCE: DOE (1991)

LOCATION OF BIG DRY CREEK BASIN AND WATER DISTRICT BOUNDARIES

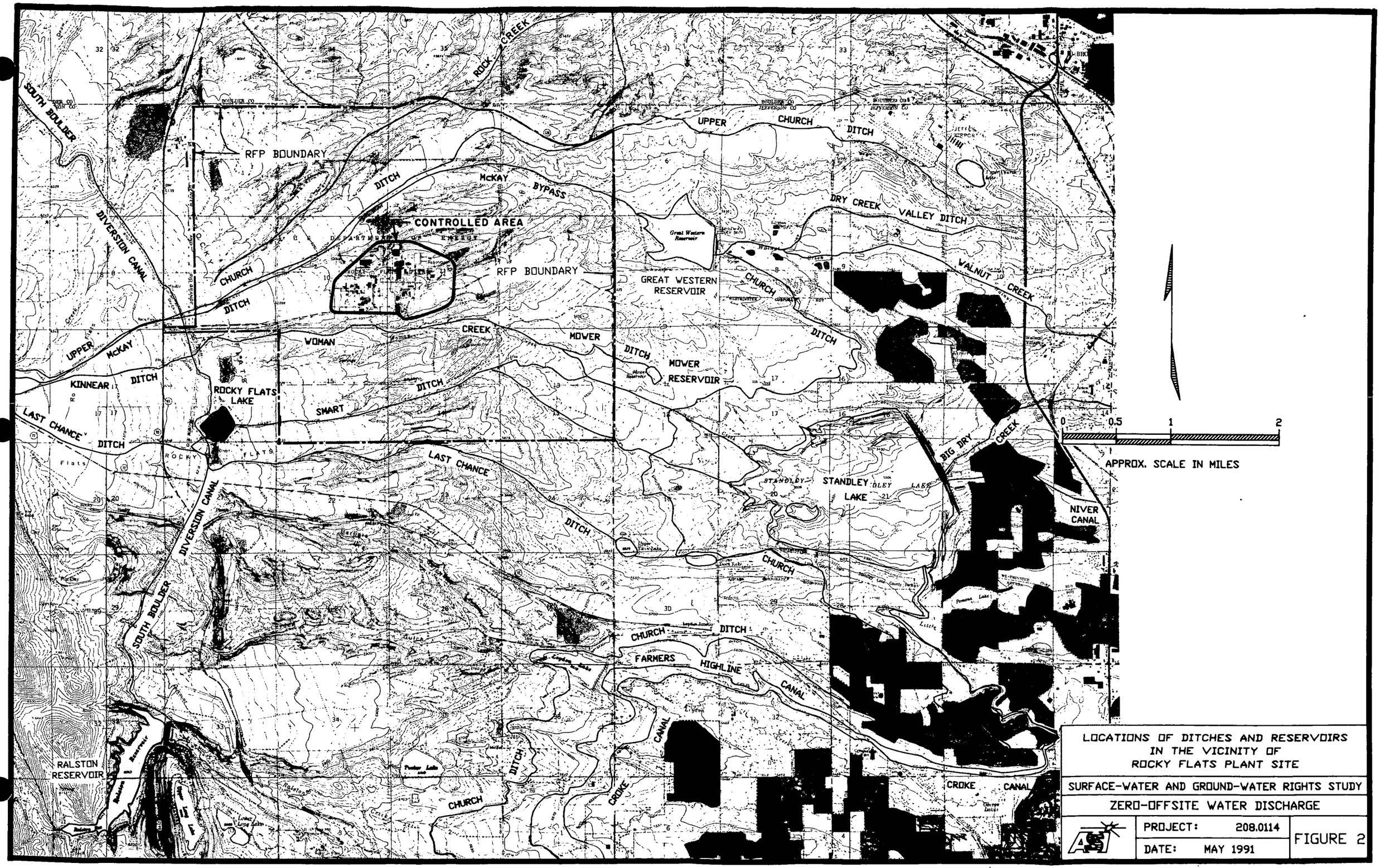
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: APR 1991

FIGURE 1



LOCATIONS OF DITCHES AND RESERVOIRS
IN THE VICINITY OF
ROCKY FLATS PLANT SITE

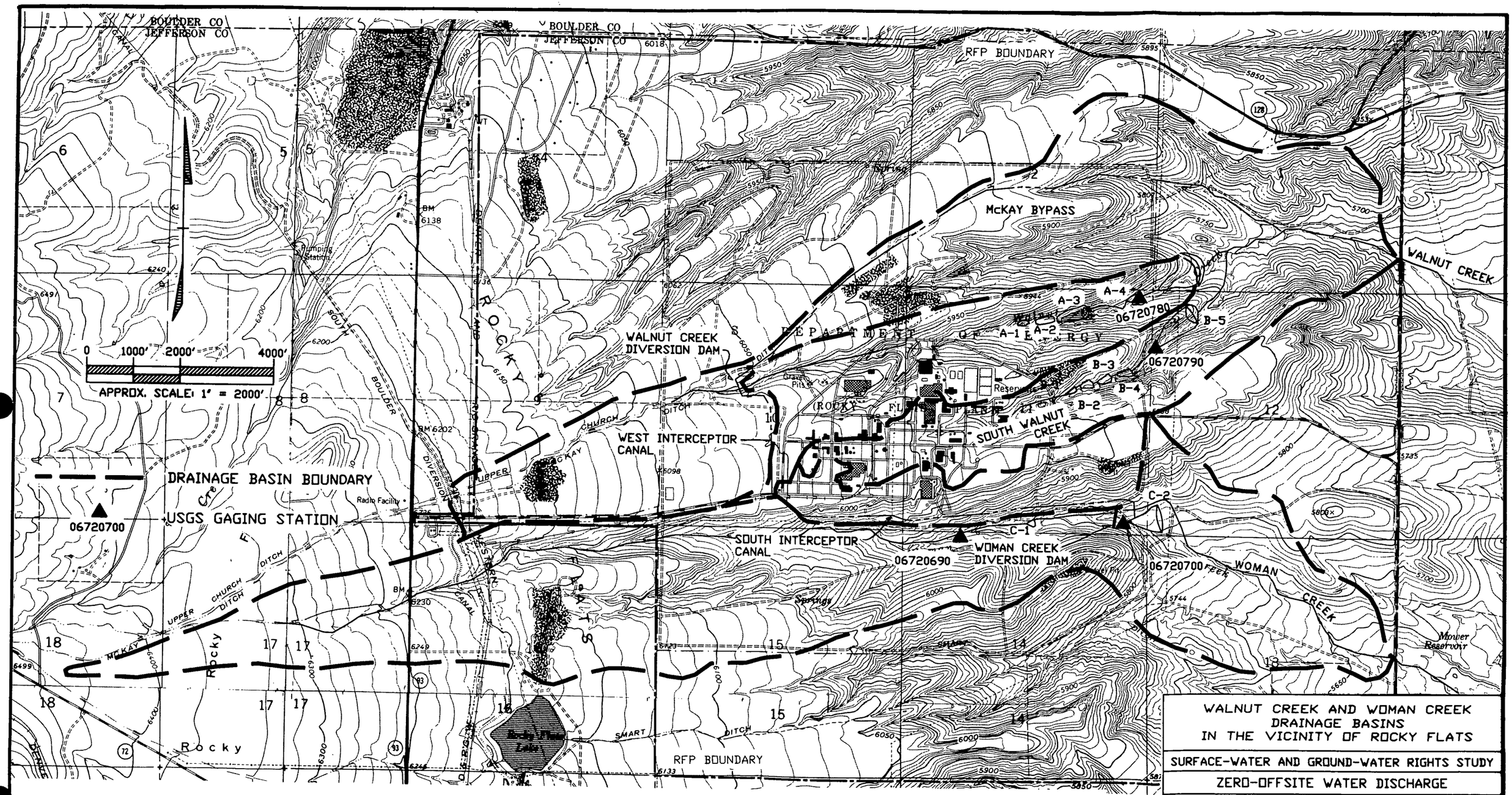
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO-OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: MAY 1991

FIGURE 2



WALNUT CREEK AND WOMAN CREEK DRAINAGE BASINS IN THE VICINITY OF ROCKY FLATS

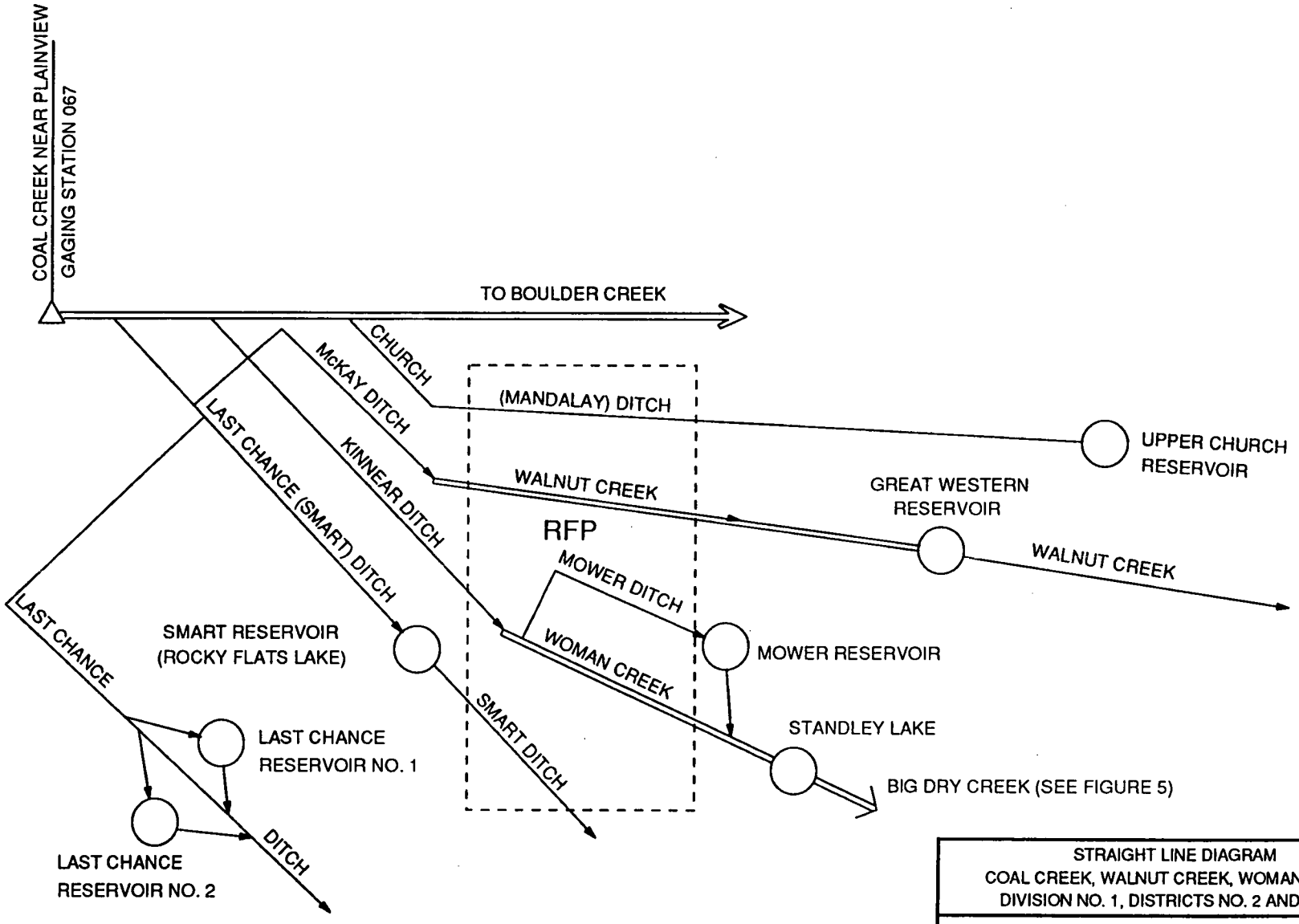
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO-OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: MAY 1991

FIGURE 3



SOURCE: DOE, 1991

STRAIGHT LINE DIAGRAM
COAL CREEK, WALNUT CREEK, WOMAN CREEK
DIVISION NO. 1, DISTRICTS NO. 2 AND NO. 6

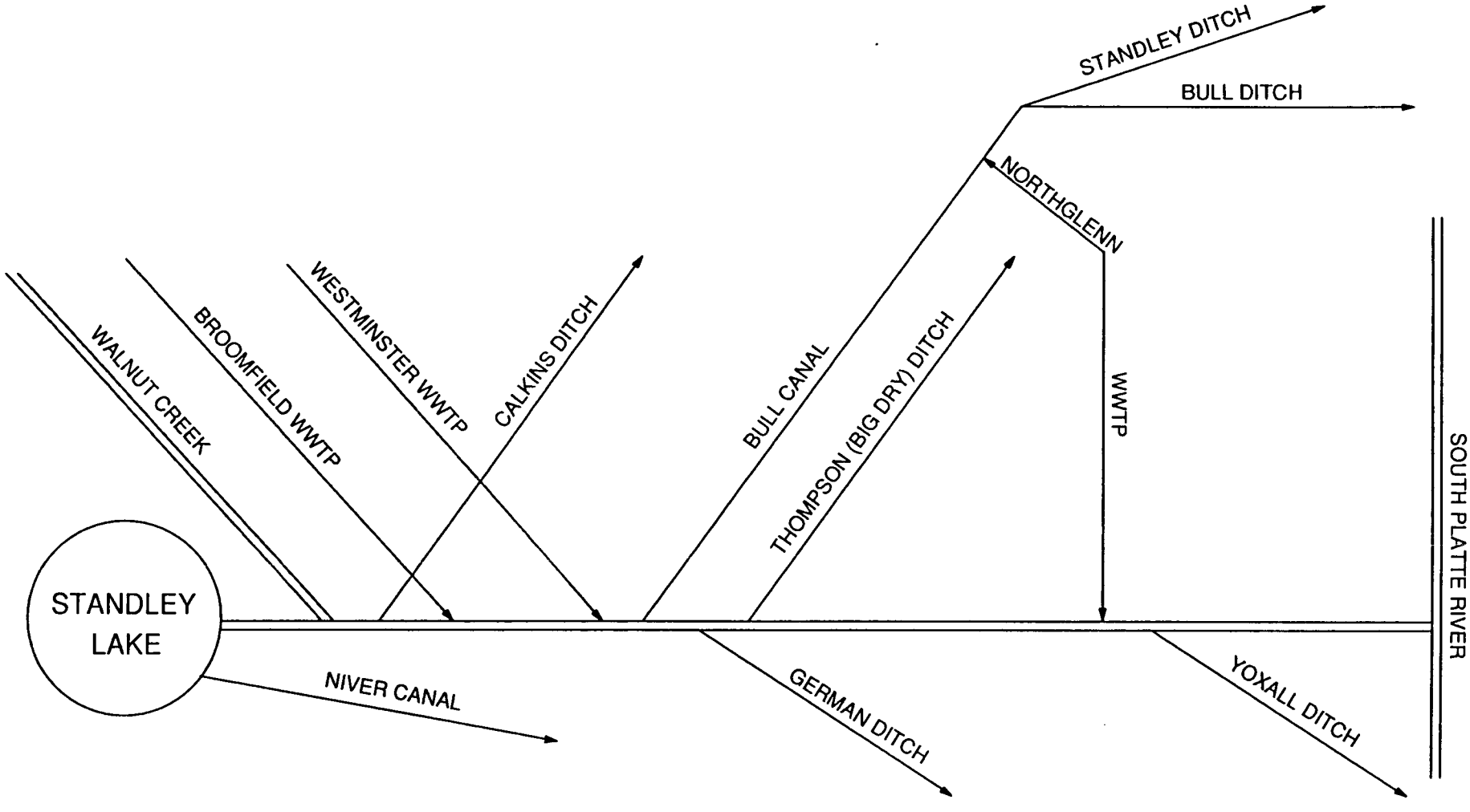
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO OFFSITE WATER DISCHARGE

PROJECT: 208.0114

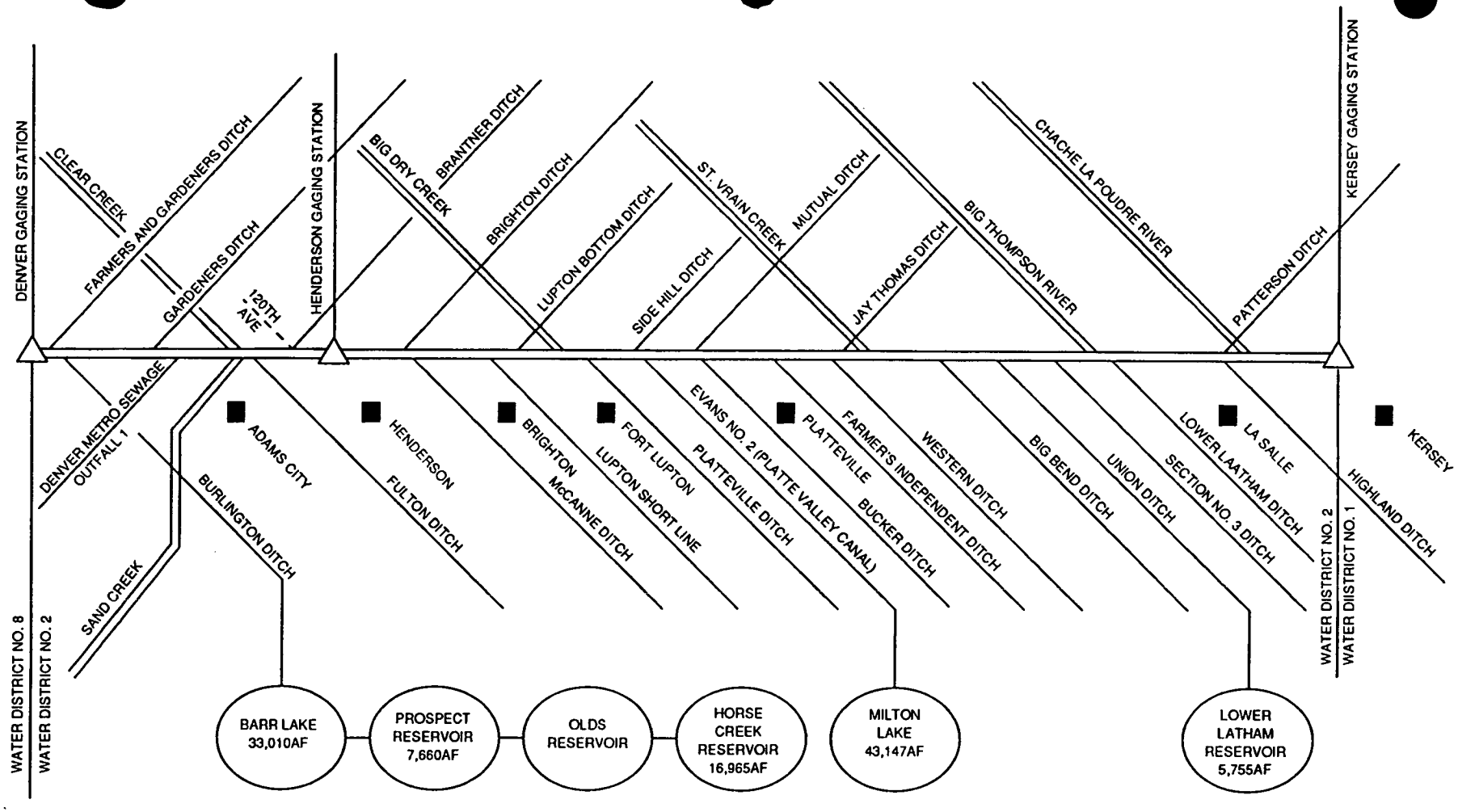
DATE: MAY 1991

FIGURE 4



SOURCE: DOE, 1991

STRAIGHT LINE DIAGRAM BIG DRY CREEK DIVISION NO. 1, DISTRICT NO. 2		
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY		
ZERO OFFSITE WATER DISCHARGE		
	PROJECT: 208.0114	FIGURE 5
	DATE: MAY 1991	



SOURCE: DOE, 1991

STRAIGHT LINE DIAGRAM
SOUTH PLATTE RIVER
DIVISION NO. 1, DISTRICT NO. 2

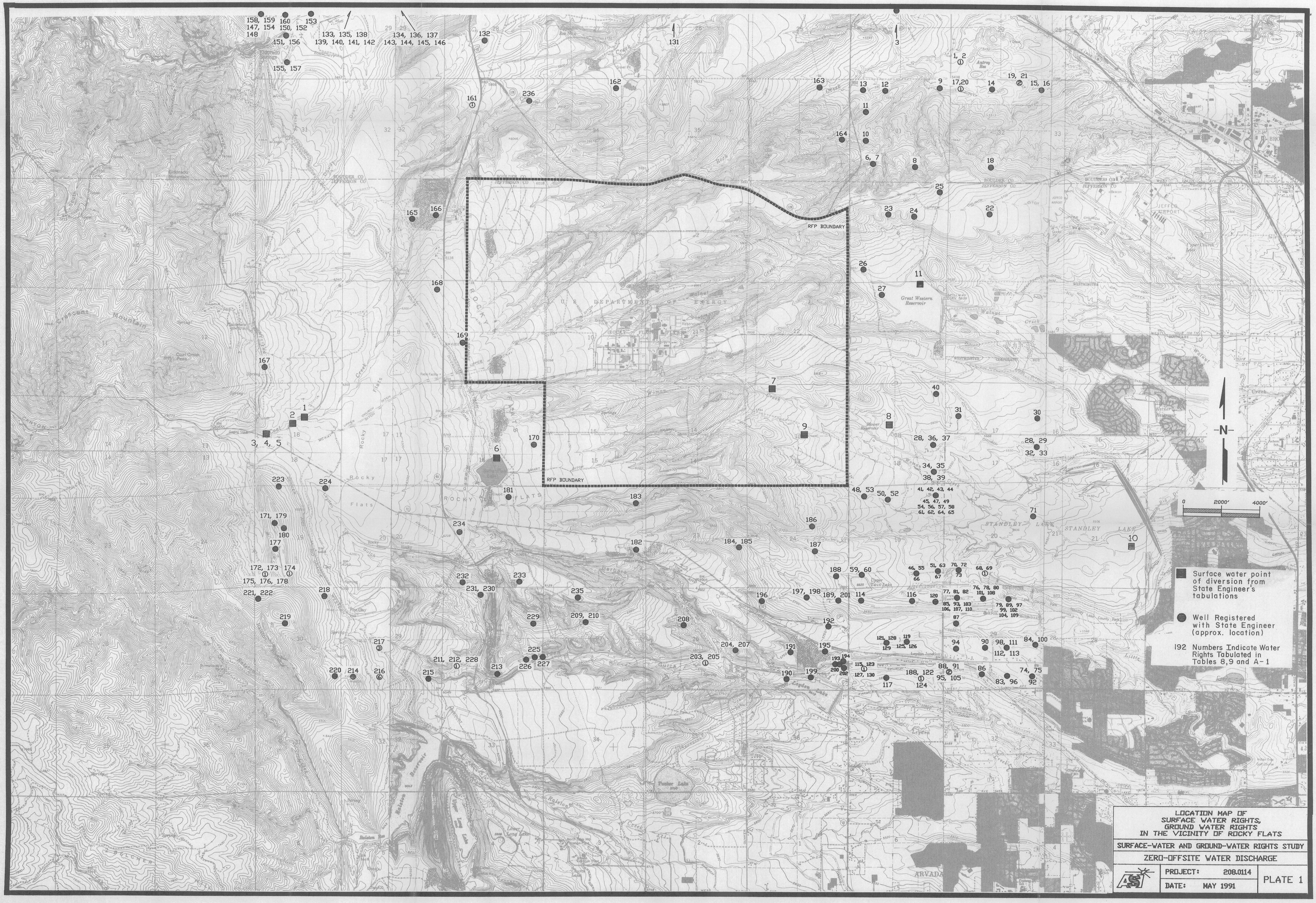
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: MAY 1991

FIGURE 6



LOCATION MAP OF SURFACE WATER RIGHTS, GROUND WATER RIGHTS IN THE VICINITY OF ROCKY FLATS

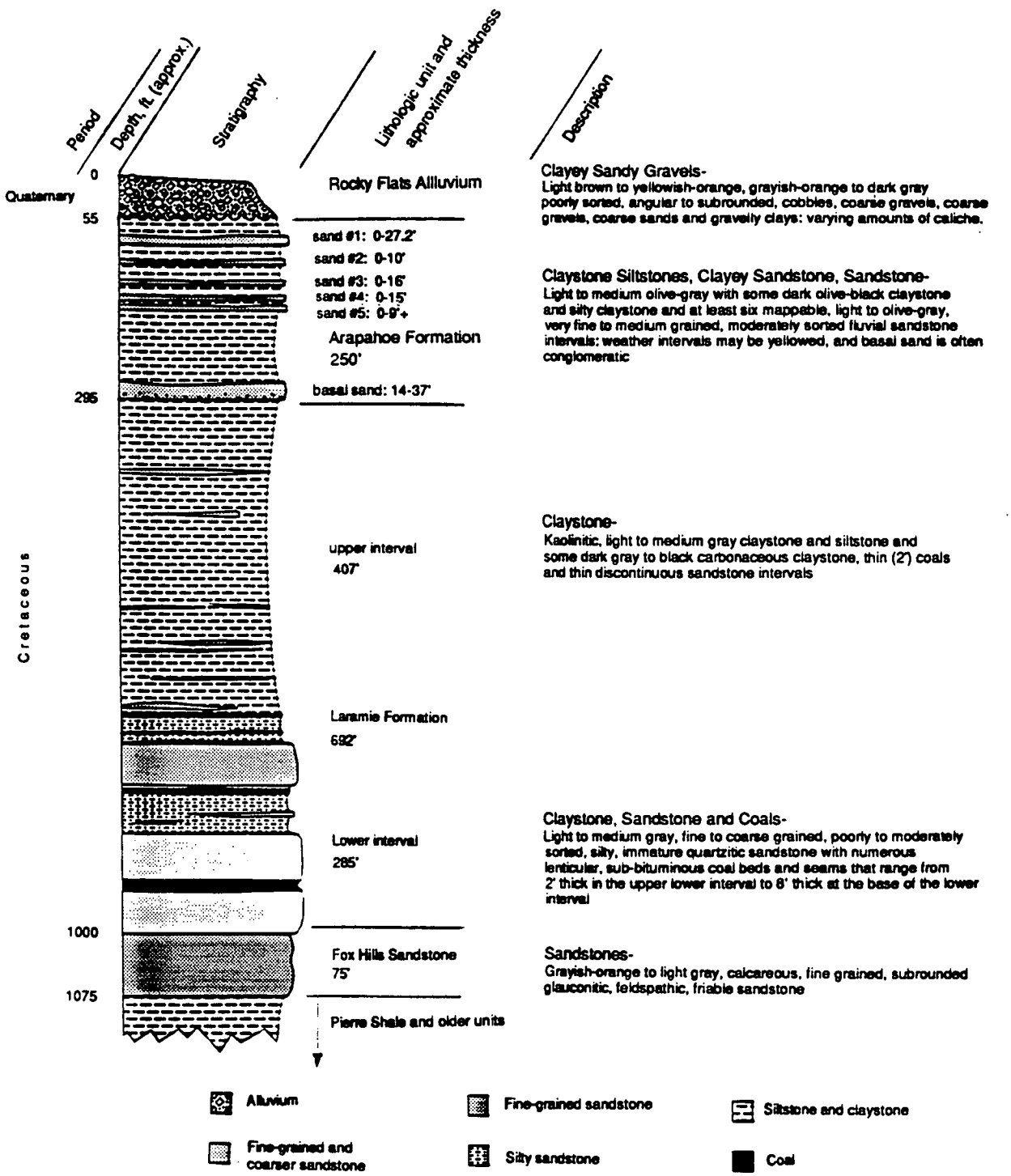
SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO-OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: MAY 1991

PLATE 1



GENERALIZED STRATIGRAPHIC SECTION
ROCKY FLATS PLANT

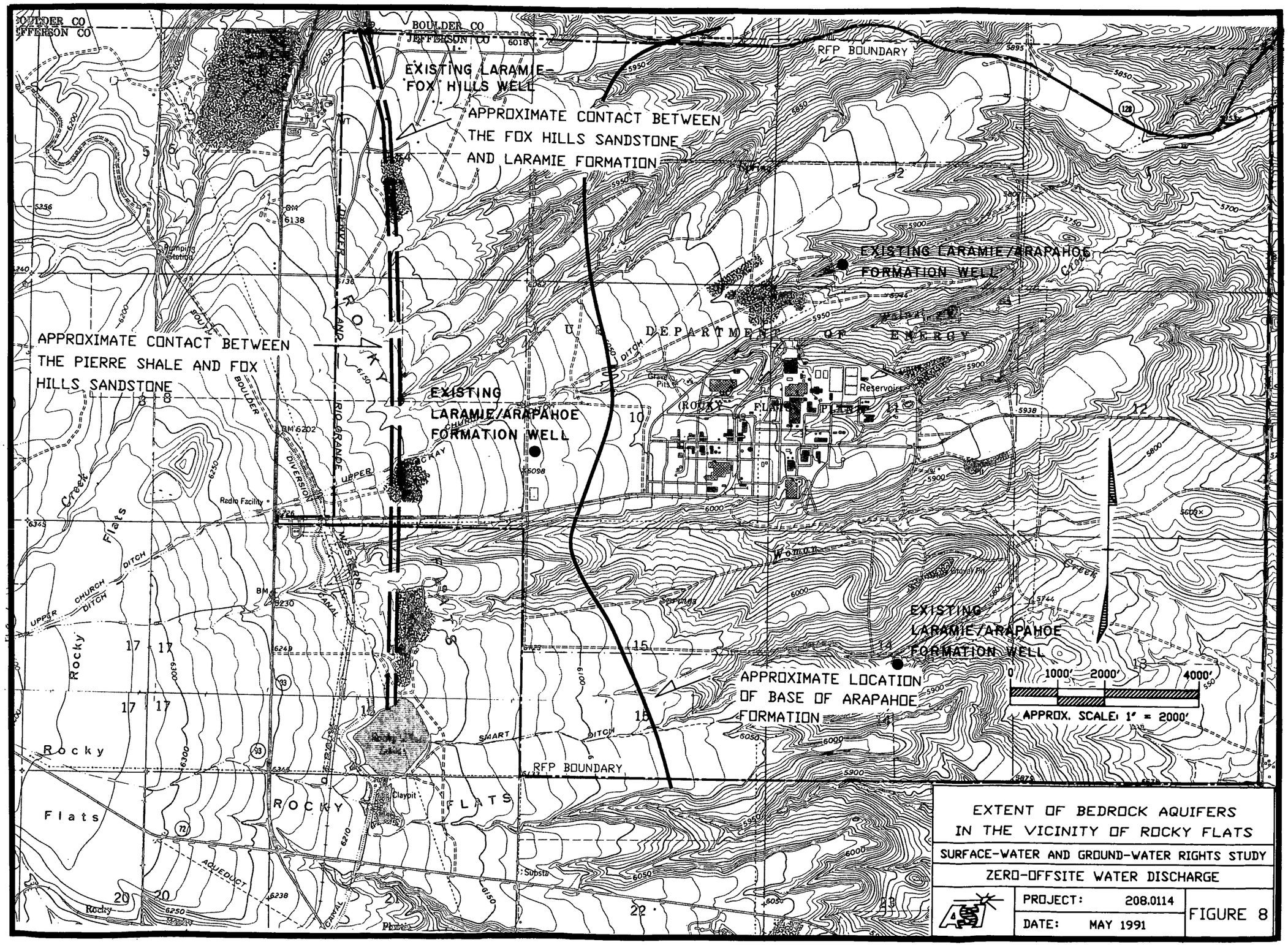
SURFACE-WATER AND GROUND-WATER RIGHTS

ZERO OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: MAY 1991

FIGURE 7



EXTENT OF BEDROCK AQUIFERS IN THE VICINITY OF ROCKY FLATS

SURFACE-WATER AND GROUND-WATER RIGHTS STUDY

ZERO-OFFSITE WATER DISCHARGE

PROJECT: 208.0114

DATE: MAY 1991

FIGURE 8